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A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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APPLIED MECHANICS REVIEWS

VOL. 5, NO. 1 MARTIN GOLAND *Editor* JANUARY 1952

REVIEW OF THE FATIGUE OF MATERIALS FIELD

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GENERAL

FATIGUE failures continue to be one of the problems involved in design and operation of machinery and transport vehicles. In the operation of Liberty ships in three recent years, about 100 propellers were lost at sea due to fatigue failures of the screwshaft (1).[1] There have been only two catastrophic aircraft failures due to structural fatigue failure, but the minor fatigue failures of "nuisance" category, which are corrected in maintenance operations and reported to C.A.A., have been occurring at the rate of about 30 per month (2). Fatigue cracks appearing in railway axles require considerable inspection and maintenance programs. Fatigue fractures occur in various types of machinery, including gas turbines. Recently fatigue cracks have been discovered in the Boulder transmission lines (3). These lines have a right-of-way of 325 miles and have been in service 15 years.

STATISTICAL ASPECTS

Although it has been realized for some time that fatigue data are essentially statistical in nature, it is only comparatively recently that steps have been taken to attempt to bring forth practical procedures in the reporting of fatigue data and the planning of fatigue investigations. To be sure, a similar problem exists in considering data from other materials tests; for example, tensile strength (4, 5), except that the representation is simpler—*S*, *P* diagram for tensile tests; *S*, *P*, *N* diagram for fatigue tests, where *S* is stress, *N* number of cycles to failure, and *P* probability (6, 7). Furthermore, the fatigue relation (*S*, *N* diagram) sometimes involves an asymptotic limit, in which case procedures of a "go-no-go" type (8) are indicated, similar to those used in testing the energy required to detonate explosives or in testing the lethal effects of various strengths of an insecticide. Ransom and Mehl (9) reported the results of fatigue tests of 80 specimens from the same bar of steel. By random selection of data they produced 8 curves, each curve seemingly "well defined" by 10 points. However, the endurance limits differed as much as 20%. While there is reason to suspect that this is a greater than average "scatter," yet the results illustrate an important point. If an investigation involves small differences, such as in various strength theories (difference between maximum shear and shear energy criteria is 15%), it is clear that statistical methods are necessary. Also in comparing experimental notch factors with theoretical factors, especially for low factors, the fatigue results should be determined with better-than-usual accuracy, i.e., on a statistical basis, if the results are for scientific purposes.

Apart from improving accuracy of data, there is another reason for studying the statistical aspects of fatigue, namely, the consideration of "size effect" (5). This is important because large members are weaker in fatigue than tests on small specimens would indicate. While a complete theory has not as yet been established, it is safe to say that the concept of statistical behavior is a necessary part of the explanation of "size effect."

Another interesting aspect of application of statistical theory is the possibility of explaining, at least partly, the understressing effect in fatigue (10).

It seems certain that in the next decade the statistical aspect of fatigue will be emphasized in numerous publications.

SPECTRUM PROBLEM

The usual fatigue test operates at constant amplitude, but with actual apparatus in service this is seldom the case. An airplane is subjected to gust loads of various magnitudes; automobiles and rail vehicles are subjected to a variety of load conditions. This brings about the "spectrum problem" in fatigue, i.e., the behavior of material and structures to vibrations of varying amplitude (11, 12, 13, 14, 15). A simple design criterion which has been used is that failure occurs when the summation of cycle ratios[2] equals unity, $\sum \frac{n}{N} = 1$. There is evidence to show that considerable departures from this simple relation can be obtained. Work on the "spectrum problem" is proceeding in two directions: measurement of service stresses (13, 14), and fatigue tests of materials (16) and structures—such as a full-scale airplane wing (18, 19)—at "mixed" amplitudes. To facilitate obtaining service data, strain counters, which record the number of times the strain exceeds the values in a stepped series, have been developed for aircraft (13) and marine (20) use. Fatigue tests at mixed amplitudes are sometimes conducted by varying the load stepwise, and sometimes by varying the load smoothly by means of a cam so as to follow a sine curve or a curve following more closely the service distribution (14). An axial fatigue testing machine has been built under NACA sponsorship wherein the spectrum is built up of a mean load and any chosen combination of alternating loads at 16 levels (14).

[1] Numbers in parentheses indicate References at end of paper.

[2] Cycle ratio is the number of cycles n_1 at stress S_1 over the number of cycles N_1, required to produce failure at S_1. (Cycle ratio $C_1 = n_1/N_1$.)

NOTCH EFFECT

Usually the effect of a notch (using the term generically to denote a geometrical variation causing stress concentration) is less than would be obtained if the stress concentration factor were fully effective. This is particularly true as the absolute size of the notch is decreased to small values. Furthermore, the effect is dependent on material, being generally less in materials such as annealed or normalized steels as compared to quenched and tempered steels. Considerable work is in progress in establishing values which will be useful in design (17, 18, 19, 20). Since the critical section of a machine part nearly always involves some degree of stress concentration, it is clear that the work on notch effect in fatigue will be of considerable interest. Fatigue tests of various cross-sectional shapes show that lower mean values are obtained for larger volumes of material at the peak-stress region (25, 26). This indicates that statistical theory can at least partly explain the above-mentioned variation of the fatigue notch factor. As the notch radius becomes very small, approaching the grain size of the material, factors based on the usual assumptions of the theory of elasticity do not, of course, apply. Neuber (27) has suggested a method of modifying the theoretical factors; others have proceeded along somewhat similar lines. These are empirical results and have a certain usefulness. A more basic approach would be desirable, but it is realized that the problem of analyzing the detailed behavior of an aggregate is indeed a complicated one.

COMBINED STRESSES

A completely satisfactory general failure law for fatigue does not exist at present. For tension and torsion fatigue tests of ductile materials, it appears that the von Mises criterion provides a reasonably good interpretation of existing data, at least for design purposes. However, if compression tests are considered, it is clear that a more generally applicable failure relation is needed, perhaps approaching a paraboloid (28, 29). An interesting paper on compression fatigue tests was recently presented (30). Attempts have been made to formulate for design use some general relations for combined steady and variable stresses corresponding to failure for various numbers of cycles (12, 31). Additional experimental work is needed, particularly at small numbers of cycles.

PROCESSING EFFECTS

Investigations of the effects of shop processes on fatigue of members have been particularly fruitful (32, 33, 34, 35). Shot-peening has been shown to be highly effective in increasing the fatigue strength under certain conditions (36, 37). An attempt has been made to evaluate, by means of an x-ray method, induced residual stresses, their change due to fatigue stressing and their effect on fatigue strength (38). It is hoped that further work will result in relating the processing tests in such a way that each variation, for example a dimensional one, does not represent a new case.

FATIGUE AT ELEVATED TEMPERATURES

The continued development of the gas turbine, especially in the turbojet and turboprop aviation fields, has emphasized the need of fatigue data at elevated temperatures (39, 40, 41). Materials which normally show an endurance limit at room temperature are found at elevated temperature to continually decrease in fatigue strength as a function of number of cycles. The problem is a complicated one since at elevated temperature creep and fatigue may be occurring simultaneously; consequently, time, as well as number of cycles, enters as a variable. Metallurgical changes can also occur in gas turbine materials during the period involved in testing. Failure due to creep alone at elevated temperatures starts with grain-boundary separation; fatigue failure which is normally transcrystalline can be influenced by creep-rupture separations due to a steady stress component. More information is needed with regard to the detailed behavior of materials at elevated temperatures in order to explain the experimental results obtained.

FUNDAMENTAL STUDIES

Some interesting results of fundamentals of fatigue have been contributed, but much more work is needed in this general area (42, 43, 44, 45, 46, 47, 48, 49). Since initial failure in fatigue is associated with slip lines, it is clear that research work on certain details of plastic action is also of interest in connection with fatigue. For example, the electron microscope has shown (50) "static" slip bands in aluminum to consist of numerous laminae about 200 Å thick displaced laterally about 2000 Å. The details associated with cycling have not to date been studied in this manner. Recent x-ray diffraction studies of the changes in structure due to variation of rate and direction of loading are of considerable interest (51). The mechanism of crack development and propagation, and the effect of compressive stress are in need of intensive study and research.

REFERENCES

1 Archer, S., Screwshaft casualties, *J. Amer. Soc. nav. Engrs.* **62**, p. 715, 1950.

2 Shuler, W. T., Fatigue problems in transport aircraft, *Aero Engng. Rev.*, 20–26, June 1951.

3 Garman, C. P., Vibration fatigue in Boulder transmission lines, *Electrical West.* **104**, p. 62, 1950.

4 Peirce, F. T., Tensile tests for cotton yarns vs. "the weakest link"—theorems on the strength of long and composite specimens, *J. Text. Inst.* **17**, p. 355, 1926.

5 Weibull, W., A statistical theory of strength of materials, *Proc. roy. Swed. Inst. for Engng. Res.* no. 153 (in English); Generalstabens Litografiska Anstalts Foerlag, Stockholm, 1939.

6 Freudenthal, A. M., Planning and interpretation of fatigue tests, Paper presented at Amer. Soc. Test. Mat. Annual Meeting, Atlantic City, N. J., June 18–22, 1951.

7 Weibull, W., Statistical aspects of fatigue strength, AMR 4, Rev. 2045.

8 Statistical analysis for a new procedure in sensitivity experiments, AMP Rep. no. 101.1R, Statistical Research Group, Princeton, no. 40, 1944.

9 Ransom, J. T., and Mehl, R. F., The statistical nature of the endurance limit, *Metals Trans.* **185**, p. 364, 1949.

10 A short presentation was given by E. Epremian at Amer. Soc. Test. Mat. Annual Meeting, Atlantic City, N. J., June 18–22, 1951.

11 Putnam, A. A., An analysis of life expectancy of airplane wings in normal cruising flight, *Nat. adv. Comm. Aero. Rep.* no. 805, 1945.

12 Walker, P. B., Fatigue of aircraft structures, *J. roy. aero. Soc.* **53**, p. 763, 1949.

13 Wills, H. A., The life of aircraft structures, *Proc. second int. Aero Conf.*, Inst. Aero. Sciences, New York, p. 361, 1949.

14 Dryden, H. L., Rhode, R. V., and Kuhn, P., The fatigue problem in airplane structures, Paper presented at Conference on the Fatigue and Fracture of Metals, held at Mass. Inst. Tech., June 19–22, 1950.

15 Lundberg, B., and Wallgren, G., A study of some factors affecting the life of aircraft parts, AMR 4, Rev. 1592.

16 Dolan, T. J., Richart, F. E., and Work, C. E., The influence of fluctuations in stress amplitude on the fatigue of metals, AMR 4, Rev. 2057.

17 Smith, F. C., Howard, D. M., Smith, Ira, and Harwell, R., Fatigue testing machines for applying a sequence of loads of two amplitudes, AMR **4**, Rev. 3241.

18 Johnstone, W. W., Patching, C. A., and Payne, W. O., An experimental determination of the fatigue strength of CA-12 Boomerang wings, *Austral. Aero. Res. Lab. Rep.* SM-16, Melbourne, Sept. 1950.

19 Fearnow, D. O., Investigation of the fatigue strength of full-scale airplane wing structures, *Nat. adv. Comm. Aero. Res. Memo.* L51 D13a, 1951.

20 Jasper, N. H., The TMB strain cycle gage and counter: An instrument for the statistical determination of the strain history of structures, Paper presented at Soc. exp. Stress Anal. Meeting, May 1951.

21 Gough, H. J., Engineering steels under combined cyclic and static stresses, AMR **4**, Rev. 3564.

22 Phillips, C. E., and Heywood, R. B., Size effect in fatigue of plain and notched steel specimens loaded under reversed direct stress, Inst. Mech. Engrs., London, Abstract in *Engineering* **191**, p. 285, March 2, 1951.

23 Templin, R. L., Howell, F. M., and Hartmann, E. L., Effect of grain direction of fatigue properties of aluminum alloys, *Prod. Engng.* **21**, pp. 126–130, July 1950.

24 Grover, H. J., Bishop, S. M., and Jackson, L. R., Fatigue strengths of aircraft materials; Axial-load fatigue tests on unnotched sheet specimens of 24S-T3 and 75S-T6 aluminum alloys and of SAE 4130 steel, AMR **4**, Rev. 2508, 4470, 4471.

25 Fuller, F. B., and Oberg, T. T., Fatigue characteristics of rotating-beam versus rectangular cantilever specimens, *Proc. Amer. Soc. Test. Mat.* **47**, p. 665, 1947.

26 Dolan, T. J., McClow, J. H., and Craig, W. J., The influence of shape and cross section of the flexural fatigue strength of steel, AMR **4**, Rev. 1593.

27 Neuber, H., Kerbspannungslehre, Translation published by Edwards Publ. Co., Ann Arbor, Mich., 1946.

28 Meldahl, A., A new graphical method of representing strength characteristics, *Brown Boveri Rev.*, p. 260, Aug. 1944 (see Fig. 10).

29 Nadai, A., Theory of flow and fracture in solids, AMR **4**, Rev. 2470.

30 Newmark, N. M., Mosborg, R. J., Munse, W. H., and Elling, R. E., Fatigue tests in axial compression, Paper presented at Amer. Soc. Test. Mat. Annual Meeting, Atlantic City, N. J., June 18–22, 1951.

31 Weisman, M. H., and Kaplan, M. H., The fatigue strength of steel through the range from $^1/_2$ to 30,000 cycles of stress, AMR **4**, Rev. 3880.

32 Almen, J. O., Fatigue loss and gain by electroplating, *Prod. Engng.* **22**, 109–116, June 1951.

Fatigue durability of prestressed screw threads, *Prod. Engng.* **22**, 153–156, April 1951.

33 Bachman, W. S., Fatigue testing and development of drill pipe-to-tool joint connections, *Petroleum Eng.* **23**, p. B36, Feb. 1951.

34 Logan, H. L., Effect of chromium plating on the endurance limit of steels used in aircraft, *Proc. Amer. Soc. Test. Mat.* **50**, p. 699, 1950.

35 Case, S. L., Berry, J. M., and Grover, H. J., Fatigue strength of large notched bars surface-hardened by gas heating and by induction heating, Paper presented at Detroit meeting of Amer. Soc. for Metals, Oct. 15–19, 1951.

36 Almen, J. O., Fatigue weakness of surfaces, *Prod. Engng.* **21**, 117–140, Nov. 1950.

37 Horger, O. J., Stresses imposed by processing, *Soc. auto. Engrs. quart. Trans.* **5**, no. 3, p. 393, July 1951.

38 Rosenthal, D. and Sines, G., Effect of residual stress on the fatigue strength of notched specimens, Paper presented at Amer. Soc. Test. Mat. Annual Meeting, Atlantic City, N. J., June 18–22, 1951.

39 Symposium on high temperature steels and alloys for gas turbines, Special Publication of Iron and Steel Institute, Feb. 1951:

Tapsell, H. J., Fatigue at high temperatures, p. 169.

Frith, P. H., Fatigue tests at elevated temperatures, p. 175.

Gresham, H. E., and Hall, B., Hot fatigue testing, p. 181.

40 High temperature properties of metals, Special Publication of Amer. Soc. for Metals, 1951:

Grover, H. J., and Cross, H. C., High temperature fatigue testing, p. 73.

41 Ferguson, R. R., Effect of surface finish on fatigue properties at elevated temperatures, *Nat. adv. Comm. Aero. Res. Memo.* 351D17, June 26, 1951.

42 Feltham, P., Fatigue in metals, *Iron and Steel* (British), p. 434, Oct. 1948.

43 Boas, W., Theories of the mechanism of fatigue fracture, *Metaux et Corrosion* **25**, p. 100, 1950.

44 Wood, W. A., The behavior of the lattice of polycrystalline iron in tension, *Proc. roy. Soc. Lond. Ser. A.*, **192**, p. 218, 1947–48. See reference for previous work of Wood and Smith.

45 McClintock, F., Fatigue tests of single crystals of ingot iron, Paper presented at First U. S. Nat'l. Cong. of Appl. Mech., Chicago, June 11–16, 1951.

On the direction of fatigue cracks in polycrystalline ingot iron, Paper presented at Amer. Soc. mech. Engrs. Annual Meeting, Nov. 25–30, 1951.

46 Bennett, J. A., A study of fatigue in metals by means of X-ray strain measurement, AMR **4**, Rev. 4099.

47 Cox, H. L., Fracture by fatigue, Lecture III. The fracture of metals, published by the Institution of Metallurgists (British), p. 42, 1950.

48 Machlin, E. S., Dislocation theory of the fatigue of metals, AMR **1**, Rev. 830.

49 Sinclair, G. M., and Craig, W. J., Influence of grain size on work hardening and fatigue characteristics of alpha brass, Paper presented at Amer. Soc. for Metals Meeting, Pittsburg, Pa., Jan. 31, 1952.

50 Heidenreich, R. D., and Shockley, W., Study of slip in aluminum crystals by electron microscope and electron diffraction methods, AMR **2**, Rev. 737.

51 Wood, W. A., and Head, A. K., Some new observations on the mechanism of fatigue in metals, Rev. 128 in this issue.

Communications

Correction to AMR 4, Rev. 3236.

In line 3 please read "motion of markings" instead of "motion of matter."

Theoretical and Experimental Methods

(See also Revs. 45, 64, 166, 221, 253, 255, 276)

1. Joos-Kaluza, Higher mathematics for the practitioner [Höhere Mathematik für den Praktiker] 5th ed., Leipzig, Johann Ambrosius Barth, 1951, xii + 373 pp., 90 figs. DM 23.

Book is an introduction to certain mathematical tools which, in the opinion of the authors, should be useful to workers in engineering and the natural sciences. It differs from similar books

written in the English language primarily in its intent. It is addressed apparently to readers who have forgotten much of their original mathematical training. Accordingly, the first part is essentially a refresher course in certain topics from algebra and analytical geometry, and in differential and integral calculus. The remaining chapters treat Taylor and Fourier series, certain frequently occurring differential equations (ordinary, as well as partial), a brief introduction to the calculus of variations and to functions of a complex variable. These topics are, it is felt, well chosen for their purpose.

The coauthors of the book have again demonstrated their faculty of presenting mathematical topics with clarity and precision. They have managed to avoid the mathematical vernacular as well as excessive verbosity. Over 200 problems, including their solutions, are appended to the text. R. Drenick, USA

2. **Zurlinden, R., Scheme for a small calculating machine** (in French), *Bull tech. Suisse Rom.* **77,** 16, 216–217, Aug. 1951.

The requirements of a small desk computer are outlined.

Gilbert W. King, USA

3. **Artobolevskiĭ, I. I., Mechanism for the solution of quadratic equations of the type** $x^2 - px + q = 0$ (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **79,** 3, 401–403, July 1951.

This is a mechanization of a well-known nomogram for the graphical solution of the quadratic equation. See "The calculus of observations" by E. T. Whittaker and G. Robinson, 1924, p. 129. Michael Goldberg, USA

4. **Llewellyn, F. J., A mechanical-electrical unit for calculating structure amplitudes,** *J. sci. Instrum.* **28,** 8, 229–230, Aug. 1951.

A mechanical-electrical unit for the rapid systematic evaluation of functions of the type

$$\begin{Bmatrix} \sin \\ \cos \end{Bmatrix} 2\pi hx \cdot \begin{Bmatrix} \sin \\ \cos \end{Bmatrix} 2\pi ky \cdot \begin{Bmatrix} \sin \\ \cos \end{Bmatrix} 2\pi lz$$

is described.

The accuracy is of the order of 1% for hkl planes up to $h = k = l = 20$. From author's summary

5. **Sverdup, N. M., Viscosity conversion charts,** *Prod. Engng.* **22,** 8, 179–180, Aug. 1951.

Chart to convert absolute viscosity in English gravitational units to those of the metric gravitational system or to the metric cgs system; graph for conversion of kinematic viscosity in American Saybolt Universal seconds to the English units (ft^2/sec) or to centistokes. D. Mazkevich, USA

6. **Erugin, N. P., On the continuation of solutions of differential equations** (in Russian), *Prikl. Mat. Mekh.* **15,** 1, 55–58, Jan.-Feb. 1951.

A well-known theorem on the continuation of integral curves is generalized for a system of differential equations.

E. Leimanis, Canada

7. **Erugin, N. P., Some general questions in the theory of stability of motion** (in Russian), *Prikl. Mat. Mekh.* **15,** 2, 227–236, Mar.-Apr. 1951.

Consider the system of differential equations

$$dx_i/dt = X_i(x_1, \ldots, x_n, t) \; (i = 1, 2, \ldots, n) \qquad [*]$$

where X_i are real-valued and continuous for all $-\infty < t < \infty$ and $-\infty < x < \infty$. First, the author reproves two theorems of Wintner [*Amer. J. Math.* **67,** 277–284, 1945] concerning the existence of solutions of the whole t-axis; in addition, making use of the theorem of his previous paper [see preceding review], he proves the following theorem:

Assume that the X_i satisfy the condition

$$|x_1X_1 + \ldots + x_nX_n| \geq rL(r) \text{ for } r > r_0$$

where $L(r) > 0$ and is continuous for all $0 \leq r < \infty$ and $r_0 \int^{\infty} dr/L(r)$ is bounded as $r \to \infty$. Then the system [*] has a solution which either cannot be continued outside a finite interval $|t - t_0| \leq M$ or is bounded for $-\infty < t < \infty$.

Moreover, autonomous systems of equations with one degree of freedom and with n degrees of freedom are considered and various assumptions concerning the nature of their right-hand sides and the nature of the unperturbed motion are made. A certain number of theorems are proved concerning the existence of limit cycles, stability or instability of solutions, as well as the nature of the boundary of domains in which stability or instability takes place or a limit cycle exists.

E. Leimanis, Canada

8. **Helfenstein, H., On a special Lamé differential equation, with application to an approximate resonance formula of Duffing's vibration equation** (in German), Thesis, ETH, Zürich, Prom. no. 1985, 66 pp., 1950.

Topic of paper is undamped forced oscillation with cubic restoring force. The choice of an elliptic function is proposed for the impressed force rather than the conventional circular one. It is shown that both methods lead to similar results. However, the advantage of the proposed method is twofold: (1) The equation relating the amplitude and period of the impressed force with those of the stationary oscillatory solutions can be written explicitly; (2) the problem of stability leads to a special Lamé, rather than a Mathieu equation as the conventional solution does, and, hence, can be discussed rigorously and explicitly. These advantages suggest that periodic forcing functions in general are best approximated by elliptic rather than circular functions. A chapter in the paper outlines a method of approximating periodic functions with elliptic ones. R. Drenick, USA

9. **Gorodskiĭ, D. A., A simple method of numerical solution of algebraic equations** (in Russian), *Elektrichestvo* no. 3, 65–66, Mar. 1951.

For approximately locating complex zeros of a polynomial $f(p)$, author recommends evaluating f for $|p| = \text{const}$ and arguments $0°, 30°, 60° \ldots$. Thus a curve is generated in the plane of $f(p)$ which may approach the origin.

Next, suppose p_1 and p_2 approximate a pair of conjugate complex roots. Form $(p - p_1)(p - p_2) = p^2 + ap + b$. Divide quadratic into $f(p)$ obtaining remainder $mp + n$. For arbitrary small variations Δ_1 and Δ_2, divide $p^2 + (a + \Delta_1)p + b$ and $p^2 + ap + b + \Delta_2$, each into f obtaining remainders $m_1p + n_1$ and $m_2p + n_2$. If $\Delta m_i = (m_i - m)/\Delta_i$ and $\Delta n_i = (n_i - n)/\Delta_i$, then for $\Delta m_1\Delta a + \Delta m_2\Delta b + m = \Delta n_1\Delta a + \Delta n_2\Delta b + n = 0$, $a + \Delta a$ and $b + \Delta b$ determine improved values of p_1 and p_2.

This method stands in relation to that of Hutchinson [*J. Math. Phys.* **23,** 69–74, 1944] precisely as does *regula falsa* to Newton's for real roots. A. S. Householder, USA

10. **Luke, Y. L., and Ufford, D., On the roots of algebraic equations,** *J. Math. Phys.* **30,** 2, 94–101, July 1951.

A method is described for finding the roots of a polynomial equation. An iterative procedure is used to factor the given polynomial into any number of subpolynomials of lower degree.

The method is an extension of Lin's work [title source **20,** 231–242, 1941; **23,** 60–77, 1943]. The given polynomial

$$\sum_{i=0}^{n} A_i x_i = 0;\ A_n = 1$$

may be factored into two polynominals

$$(\sum_{i=0}^{m} b_i x_i)(\sum_{x=0}^{n-m} a_i x_i) + \sum_{i=0}^{m-1} r_i x_i = 0;\ b_n = a_{n-m} = 1$$

and, by an iteration process, the remainder terms r_i are forced to vanish. By repeated application of this procedure to the two subpolynomials, an algorithm is defined which enables one to factor the original polynomial into a number of subpolynomials which are factors of the original equation.

The general expressions required to separate a polynomial into any number of subpolynomials are not given, but the special case of all linear factors is generalized. The question of convergence of the iteration process has not been fully answered, and the method seems to require the roots to be well separated.

In the examples given by the authors, four to six iterations are necessary to obtain the solution of a sextic equation. However, if the process does converge, three quadratics are obtained without further labor. Further examples indicate procedure to be followed when iteration process is only partially convergent.

Reviewer feels that, if all the roots of the equation are required, the method is labor-saving; but the success of the method seems, in part, to depend upon separation of the roots and the absence of too many complex roots. William A. Wolfe, Canada

11. **Freeze, P. D., Bibliography on the measurement of gas temperature,** Nat. Bur. Stands. Circ. 513, 14 pp., Aug. 1951.

12. **Landweber, L., An iteration formula for Fredholm integral equations of the first kind,** *Amer. J. Math.* **73,** 3, 615–624, July 1951.

Author gives iteration formula which is better adapted for computational purposes than one due to Schmidt and Picard [*Math. Ann.* **63,** 79–97, 1907]. Present iteration procedure does not depend on the knowledge of certain eigenvalues and eigenfunctions as in the Schmidt-Picard theory.

Three theorems concerning the convergence of the procedures are proved. In particular, it is shown that successive iterations give functions which satisfy the integral equation approximately in the least square since, even though a solution of the itegral equation does not, strictly speaking, exist. This last fact is important since it often occurs in practical problems.

R. C. Roberts, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 3, 219)

13. **van der Woude, W., The twofold significance of the point of Ball and the points of Burmester and some other points in the motion of the plane rigid system,** *Proc. K. Ned. Akad. Wet. Ser. A,* **54** = *Indagationes Math.* **13,** 117–122, 1951.

The points in a moving plane which, momentarily, trace straight lines lie on a circle called the inflection circle. At one of these points, called the Ball point, the path has contact of the third order with its tangent. The Ball point is also on the focal curve which is the locus of the points in the moving plane whose paths have contact of at least the third order with the circle of curvature. At four of the points on this curve, called Burmester points, the contacts are of the fourth order. It is shown analytically that the inflection circle touches its envelope in the moving plane in the Ball point and that it touches its envelope in the fixed plane in a point having properties similar to the Ball point. Hitherto, the latter point has gone unnoticed. (Shall we call it the van der Woude point?) Also, it is shown that the focal curve touches its envelope in the moving plane in the four Burmester points while it touches its envelope in the fixed plane in four newly discovered corresponding points. This is an extension of a paper by Bottema [AMR **3,** Rev. 1624].

Michael Goldberg, USA

14. **Myard, F., Reversible cinematic connection, with cruised motions, alternating, dephased and sinusoidal, between a continuous rotation and *n* rectilinear translations** (in French), *C. R. Acad. Sci. Paris* **231,** 2, 108–110, July 1950.

15. **von Schelling, H., Most frequent particle paths in a plane,** *Trans. Amer. geophys. Un.* **32,** 2, 222–226, Apr. 1951.

By assuming that a particle moving with constant velocity in a horizontal plane changes the direction of its path at the end of each unit of time by an angle with a certain prescribed probability, a model of plane continuous random motions is developed. The most frequent paths among these orbits are evaluated, and a simple arrangement of them is discussed. It is found that the loci of points which have moved the same arc length from an original straight line seem to describe the dissipation of a vertical smoke column or the currents at the influx of a river into a lake. This success of the theory appears to suggest that the most frequent particle paths may be regarded as elementary units from which various types of turbulent motions might be constructed.

Louis A. Pipes, USA

16. **Vogel, T., On certain periodic motions** (in French), *C. R. Acad. Sci. Paris* **231,** 3, 207–209, July 1950.

Author suggests a method to prove the existence of periodic motions of an appendage and gives a criterion for possible stable motions. His theoretical conclusions are verified by experiments with a multivibrator of Abraham and Bloch.

H. Bilharz, Germany

17. **Béghin, H., On the notion of work in mechanics of continua** (in French), *Ann. Inst. Fourier Univ. Grenoble* **2,** 173–184, 1951.

Author describes how to overcome serious difficulties encountered in defining internal work in a so-called continuous mass when it is regarded as a system of particles. It is shown that, without introducing new experimental principles, internal work is expressible in terms of differentials $d\mathbf{T} = F \cdot V dt$ of work done on elements of continua, where V is velocity of element to which F is applied. In this way, it is necessary to consider only work done in translation and rotation of the elements, and unnecessary to account for the three rectangular dilatations of deformable elements.

Method is applied to (1) flexible belt in contact with rotating drum, (2) work in a continuous body, and (3) internal work in a flexible string.

For continua, sum over all elements of virtual work on internal, external, and inertia forces is shown to be zero. Again, it is unnecessary to consider dilatations.

Sidney Kirkby, England

18. **Eden, R. J., The Hamiltonian dynamics of nonholonomic systems,** *Proc. roy. Soc. Lond. Ser. A,* **205,** 1083, 564–583, Mar. 1951.

Primary purpose of this paper is development of a formalism which makes it possible to obtain the equations of motion of a nonholonomic system in Hamilton's canonical form, in order that the results may be applied, by analogy, to the investigation of the

fundamental quantum-mechanical equations of motion of nonholonomic systems. Since the constrained Lagrangian coordinates and associated momenta do not form a canonical set, two sets of auxiliary variables are developed which are canonically conjugate and in terms of which the constrained variables may be expressed at each instant. These are called locally free variables. Poisson brackets may then be formed with respect to the locally free variables, and it is shown that these lead to the correct equations of motion of the nonholonomic system. Hamilton's principal function must then satisfy not only the usual Hamilton-Jacoby equation, but also a set of equations corresponding to the nonholonomic constraints. These equations imply that the principal function is nonintegrable and that it is defined only in that region of coordinate space to which the system is restricted by the fact that the initial conditions must satisfy the constraint equations.

Paper is primarily of interest for its applications to the quantum mechanics of nonholonomic systems, since the usual Lagrangian approach is generally preferable in classical mechanics.

Albert A. Schy, USA

✎19. **Dimentberg, F. M., The determination of the positions of spatial mechanisms. Application of the method of "screws" to the investigation of the displacements of spatial mechanisms** [**Opredelenie polozhenii prostranstvennikh mekhanizmov. Primenenie metoda "vintov" k issledovaniyu peremeshcheni prostanstvennikh mekhanizmov**] (in Russian), Moscow, Izdat. Akad. Nauk SSSR, 1950, 142 pp.

This book is an expansion of a previous article [see AMR **4**, Rev. 3472]. The algebra of sliding vectors and finite rigid displacements, based on Clifford's numbers, was sketched in the review cited. Here it occupies the first 40 pages. The next 60 pages are devoted to four-bar linkages with all the possible types of pairs at its joints. Forty pages are given to the equations of configuration and their solution, twenty to metric conditions for the existence of passive constraints reducing cylindrical pairs to purely rotary ones. A complete set of these conditions is given for four-bar linkages with cylindrical pairs only. Twenty-eight pages deal with five-bar linkages containing three rotary and two cylindrical pairs, or four rotary and one spherical pair (in several sequences). Equations for the existence of passive contraints are stated, but not explicitly solved: Their complexity seems prohibitive. Throughout the book the mathematical labor, due to the sheer number of terms to consider, is huge in these problems (formulas spill over the page frames). This is probably a congenital feature of the problems in spatial linkages.

A. W. Wundheiler, USA

Gyroscopics, Governors, Servos

20. **Oppelt, W., Rule of thumb relations for design and adjustment of regulated processes** (in German), *Chemie-Ing.-Technik* no. 8, 190–193, 1951.

Paper deals with problem of designing process-control system so that the system will be regulated to a sufficient degree of accuracy and have a sufficiently stable response. Various basic systems are analyzed and rules of thumb are presented in tabular form so that a designer confronted with a standard process-control problem can dispense with analysis and apply these rules directly.

Paper considers proportional, floating, and proportional-plus-floating (integrating or "reset") regulators; proportional regulators where the response is damped oscillatory (frequent in hydraulic-type controllers); controlled processes which possess "self-regulation" (nonfloating) as well as ones without "self-regulation" (floating or integrating types). The existence of dead time (transmission lag) is considered in addition to transfer (exponential) lags.

Author employs (in an appendix) the Nyquist criterion in his analysis in order to establish the stability limits associated with each mode of control. He then plots these limits in a three-coordinate plot, the stability boundary appearing as a surface. He then proposes that a rule of thumb suggested by Ziegler and Nichols [*Trans. Amer. Soc. mech. Engrs.* **64**, p. 759, 1942] be applied whereby: $V_R = 0.5V_{Rkr}$; $T_n = 0.83T_{kr}$, where V_R is the regulator amplification factor, V_{Rkr} is the value of V_R just sufficient to cause instability when the regulator is acting as a purely proportional regulator, T_n is the time constant associated with the integrating or reset action, and T_{kr} is the period of oscillation of the purely proportional regulator when operating at $V_R = V_{Rkr}$. A table is presented whereby V_{Rkr} and T_{kr} may be determined for certain common modes of control. The method is clarified very effectively by a practical numerical example involving control of temperature.

The paper is of engineering value for design purposes. It does not introduce any new basic principles but it does summarize the known principles involved in a convenient and concise form. It appears reasonably correct if it is born in mind that the method is an engineering approximation. Reviewer recommends the paper to designers of process-control systems and notes that the tabulated data given could be readily applied even though the user is not acquainted with the German language used.

Ralph Kochenburger, USA

21. **Maillefer, Ch., Automatic speed regulation** (in French). *Bull. tech. Suisse Rom.* **77**, 17, 232–234, Aug. 1951.

Article discusses the problem of regulating the reel tension of a thread or cable in terms of a second-order differential equation. A few remarks are also given on regulating turbine speeds. Material is well presented and makes an interesting introduction to servomechanism theory, but is of the type found in most textbooks on mechanical vibrations. W. C. Johnson, Jr., USA

22. **Stein, T., Optimum in the regulation of hydraulic turbines** (in Italian), *Energia elett.* **28**, 4, 199–210, Apr. 1951.

Let δ_t be the temporary speed droop of the governor, δ the relative velocity variation required to reach the maximum rate of displacement of the servomotor, T_s the total governor time at maximum rate, T_i the time factor characterizing the rigidity of the dashpot. Then, calling "sluggishness" of the governor mechanism the products $\delta_t T_i$ for the dashpot tachometer and δT_s for the accelerometric governor, the optimum in the regulation process of the turbine is defined as that adjustment of the governor which, by minimum self-regulation of the network, warrants the practically shortest damping time, with minimum sluggishness. Under certain assumptions, generally warranted by the present-day construction technique of governors, author shows that both the dashpot tachometer and the accelerometric governor obey the same oscillatory laws. On the basis of this equivalence of the two types of governors and in view of the stability conditions presented by author in preceding studies, the values of the governor parameters corresponding to optimum adjustment are derived in terms of the mechanical characteristics of the unit and of the hydraulic characteristics of the water supply system. It is found that obtaining these optimum conditions is particularly easy, from the practical point of view, for the dashpot tachometer.

Getting deeper into the comparison between the two types of governors, as used in connection with hydraulic turbines and with regard to recent constructions, author shows that not only the stability of regulation is the same for both governors, but the

frequency regulation, too, is identical. On the other hand, it is much easier to reduce the flywheel effect of the unit with the dashpot tachometer than with the accelerometric governor. Finally, author points out the advisability of dropping, at least in part, the usual guarantees concerning the allowed velocity variation for full load rejection, since this would allow a larger reduction of flywheel effect without impairing the frequency regulation in everyday operation, thanks to the excellent quality of the present-day governors. P. L. Romita, Italy

23. **Kulebakin, V. S., On the selection of optimal parameters of automatic governors and follower systems** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **77**, 2, 265–267, Mar. 1951.

Author shows that the general case of any linear control system can be expressed by three simultaneous linear equations written in operational form having, as coefficients, certain differential operators and, as unknowns, the error, the coordinate of the control member, and the output. Each of these unknown quantities has a free and a forced component. Problem proposed by author consists in formulating conditions for reducing the forced component to zero. Defining as the operator-image of the forcing function such operator which, being applied to this function, reduces it to zero, author shows that the problem is solved if the operator of the forcing function contains the operator-image as a factor. The operator of the forcing function is that which appears on the right-hand side of the solution of the above system. No example is given but it is mentioned that this method is applicable to linear amplifiers. N. Minorsky, France

24. **Solodovnikov, V. V., On the dynamical exactness and optimal characteristics of follower systems and transforming devices** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **77**, 2, 269–272, Mar. 1951.

Author considers a linear dynamical system acted upon by two forces, each of which consists of one component representing a given function of time, and the other a stationary random function with zero average value and known spectral density. Under the assumption that the system has to reproduce a certain function of time with an optimum accuracy, author defines as a measure of quality of the system the sum of two errors, of which one arises from the given functions and the other is the average quadratic error due to the random functions. It is shown that the determination of these errors is reducible to that of a certain frequency-response transfer function appearing in a form of a rational fraction. Author outlines a mixed graphico-analytical method which, according to his claim, avoids the usual calculation of zeros and poles of the transfer function. The method consists of three steps: The first is analytical leading to the determination of the denominator function; the second is graphical establishing the numerator function; and the last is numerical calculation.

N. Minorsky, France

25. **Solodovnikov, V. V., Analysis and synthesis of following and regulated systems, under the influence of stationary random influences** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 11, 1648–1679, Nov. 1950.

Author investigates the effect of random disturbances on the behavior of automatic control system by the methods of mathematical statistics. As paper is purely mathematical, it cannot be abstracted here. For that reason it is sufficient to indicate its contents.

In sections I and II the definition of a statistical random process is given, and it is stated that, as the starting point for this investigation, the ergodic hypothesis is adopted. According to this hypothesis the investigation of the behavior of many similar systems occurring simultaneously is replaced by the study of the behavior of the same system at arbitrary instants of time. In sections III and IV the concepts of spectral densities and autocorrelation functions are introduced and the relation between them is outlined in section V. The next two sections deal with the definition of the average quadratic error and its calculation from the spectral density functions. Beginning with section IX, the problem of the synthesis is outlined, and it is shown that the determination of the minimum of the average quadratic error is amenable to an integral equation in terms of the autocorrelation functions.

N. Minorsky, France

26. **Zadeh, L. A., Initial conditions in linear varying-parameter systems,** *J. appl. Phys.* **22**, 6, 782–786, June 1951.

A method is given for determining the response of an initially excited linear varying-parameter system to a given input. It is shown that the prescribed initial conditions may be satisfied by superposing a linear combination of delta functions upon the input and treating the system as if it were initially at rest. Employing this fact and the concept of a system function, a general expression for the response is determined. A. W. Wortham, USA

Vibrations, Balancing

(See also Revs. 8, 150, 318)

27. **Kawashima, S., Supplement to the report on the vibration and the impact of elastic cables,** *Memo. Fac. Engng. Kyushu Univ.* **12**, 3–4, 235–243, 1951.

Paper describes experimental work intended to verify theoretical results reported previously [AMR **4**, Rev. 1927]. Measured values of frequency for a cable vibrating in the vertical plane are about 10% lower than the theoretical. Author attributes the discrepancy to damping which was not considered in the theoretical analysis. Results are also given for amplitude measurements at the center of the cable.

A third experiment is described in which the frequency is determined for a wire fixed at one end and attached at the other end to a weight free to move horizontally. In these measurements the frequency was higher than the theoretical. Author attributes this difference to less damping than in the former case, and the influence of gravity.

Reviewer finds the author's conclusions unjustifiable unless one is willing to accept as confirmation of a theory any experimental results which are within 10% or the theoretical results. Nor is the explanation advanced by the author for the discrepancies likely to go unchallenged. Damping for bodies vibrating in air does not in general have a significant effect on frequency, and any effect which does exist should not be used to explain both plus and minus discrepancies, as the author appears to have done.

E. A. Ripperger, USA

28. **Takeyama, H., On the orthogonalities of the normal functions in the lateral vibrations of plates,** *J. Japan Soc. appl. Mech.* **4**, 23, 15–18, 1951.

The more inclusive method proposed by Mathieu for proving the orthogonality of normal funtions of plates leads to unexpected expressions, incompatible with Kirchhoff's boundary conditions for a plate supported or free at the edges. This was the more confusing because Rayleigh had proved Kirchhoff's boundary conditions to be valid for any given flat plate. Author has now shown how agreement may be obtained. Having deduced Mathieu's integral with the aid of Green's function, author transforms it into orthogonal curvilinear coordinates, the contour of plate representing one component. After giving the correspond-

ing boundary conditions, the orthogonality proof is carried through for a plate supported or free at the edges.

Sven T. A. Ödman, Sweden

29. **Rosenberg, R. M., The influence of axial torque on the critical speeds of uniform shafts in self-aligning bearings,** *Univ. Wash. Engng. Exp. Sta. Bull.* no. 118, *Aero. Ser.* no. 1, 88–94, 1951.

Paper contains exact solution of critical speed problem for two cases of uniform shafts subject to axial twisting. Numerical solution is obtained and displayed only for case of self-aligning bearings at both ends. Stephen H. Crandall, USA

30. **Meller, A. G., Survey of determination of natural frequencies and modes of vibrations of compressor blades** (in French), *Rech. aéro.* no. 22, 55–66, July-Aug. 1951.

By an extension of the Ritz method, frequency and nodal lines of a nonrotating blade are calculated in good accordance with experimental results. The rotating blade is treated by the method of Myklestad, but, because this method considers only the dimension of the blade perpendicular to the axis of rotation, the change of the nodal lines is not found. W. H. Muller, Holland

31. **McGoldrick, R. T., Gleyzal, A. N., Hess, R. L., and Hess, G. K., Jr., Recent developments in the theory of ship vibration,** *David W. Taylor Mod. Basin Rep.* 739, 54 pp., Feb. 1951.

Authors consider vibratory motions of hull under external forces acting in planes perpendicular to its longitudinal axis and expressible as function of time and distance along length of ship. Hull with all loading and surrounding fluid is considered as nonuniform mass elastic system having bending and shear flexibility and distributed viscous damping proportional to mass. Instead of solving directly fourth-order linear differential equation of motion, it is reduced to a set of equations of second or lesser order on assumption that normal modes can be found. These modes and their frequencies can be obtained by sequence digital calculation or by electric analog by using method of finite differences. Paper discusses vertical and horizontal bending, torsional and coupled torsional, and horizontal bending modes. Aim of paper is to provide method for obtaining reasonable estimate of higher modes. If excitation and hull parameters are known, method can be used to determine amplitudes of forced steady-state and transient vibrations at any frequency. Authors suggest that method should indicate effect on combined amplitude of various normal mode components to be expected from alterations in longitudinal position of propellers or unbalanced machinery.

Manley St. Denis, USA

32. **McNown, J. S., On the oscillations of harbor waters under the ocean action** (in French), *C. R. Acad. Sci. Paris* **232,** 22, 2005–2007, May 1951.

It is a well-known phenomenon that in the dead water of a harbor, which is connected with oceanic water masses by a narrow passage, a periodic motion is excited by the periodic waves of the sea. This very complicated process is described by a simple mathematic formula. By linearizing the problem, presupposing the existence of a velocity potential φ dependent on time and separating the harmonic-time-function, author derives the three-dimensional potential equation for φ as in the case of the classical treatment of standing waves on limited water masses. Boundary conditions are prescribed as: The knowledge of grad φ for the time $t = 0$, vanishing normal derivative of φ at the rigid vertical walls, as well as the kinematic surface condition $\varphi_{tt} + g\,\varphi_z = 0$ (z vertical local coordinate).

Now only the particular solutions for the special case of *constant* deepness of the harbor, which are known from the classical theory, are communicated. Numerical results are given for various harbor models which are said to be in best agreement with measurements. Manfred Schaefer, Germany

33. **Graham, E. W., The forces produced by fuel oscillation in a rectangular tank,** *Douglas Aircr. Co. Rep.* SM-13748, 17 pp., Apr. 1951.

Small oscillations of fuel in partially filled tanks are investigated by potential theory. The effect is interpreted as that of an equivalent pendulum, and the period and point of suspension of the equivalent pendulum are given for five tank shapes. For some, a velocity potential satisfying all boundary conditions is not known, and the free surface shape is assumed to be a plane. Two-dimensional theory is used throughout.

R. M. Rosenberg, USA

34. **Klotter, K., Technical theory of vibrations I. The simple oscillator and vibration-measuring instruments. [Technische Schwingungslehre 1. Bd. Einfache Schwinger und Schwingungsmessgeräte] 2nd ed.,** Berlin, Springer-Verlag, 1951, xv + 397 pp. DM 46.50.

In his foreword, author claims a completeness of treatment of the vibrations of a single-degree-of-freedom system such as occurs in no other extant work. Reviewer considers this a fair statement of fact. Outside of perhaps a dozen pages devoted to problems of distributed media in the form of strings, bars, and plates, the book is concerned exclusively with the simple vibrator representable by a mass on spring. A rather full, logical, and systematic presentation of the material is given. To add the flavor of application, illustrations are taken from the field of design, but author rarely transcends the bounds of good sense by implying that structures with distributed mass and elasticity are systems of one-degree-of-freedom.

The material treated consists of free and forced vibrations, with and without damping, for nonlinear as well as linear cases. Author also examines vibrations of the Hill and Mathieu types and, in so doing, coins the word "rheolinear" for describing these vibrations which are defined by differential equations with time-variable coefficients. Other cases of time-variable coefficients are also investigated. Approximately 30 pages are devoted to this branch of vibration theory.

A lengthy treatment is given to the important topic of damped vibrations. This includes discussion of damping proportional to velocity, velocity-squared damping, as well as dry friction damping. Considerable space is devoted to a consideration of damping associated with the properties of structural materials.

A supplement of approximately 90 pages on the measurement of vibration characteristics and on measuring instruments makes obsolete the small 1943 volume by the author entitled "Messung Mechanischen Swingungen" (published since 1946 by Edwards Bros., USA). This portion of the book is quite up-to-date as evidenced by reference to SR-4 strain gages and to the book by Dobie and Isaacs entitled "Electric resistance strain gages."

References to other works, given in footnotes, while not so extensive as might be, are rather full, and an example of the most recent is Stoker's 1950 book entitled "Nonlinear vibrations." There are also a good index and a list of authors. The table of contents at the beginning of the book is specific and detailed with regard to the material in each chapter and section. Text and illustrations are sharp and clear. Many diagrams, curves, and sketches enhance the usefulness of the book.

The opinion of the reviewer is that, generally speaking, this is one of the better works on the subject.

W. H. Hoppmann, II, USA

35. **Roberson, R. E., Transverse vibrations of a free circular plate carrying concentrated mass,** *J. appl. Mech.* **18,** 3, 280–282, Sept. 1951.

Paper deals with circularly symmetric vibrations caused by a lateral blow striking concentrated mass at center of plate. Laplace transform methods are used, with δ-functions to represent effects both of blow and of concentrated mass. For modes higher than fourth, first term of asymptotic expansion of Bessel functions in solution gives approximations adequate for most purposes. Effect of very small concentrated mass on natural frequencies is shown to be considerable.

Kenneth Herbert Griffin, England

Wave Motion, Impact

(See also Revs. 27, 289, 301, 311)

36. **Schelkunoff, S. A., Remarks concerning wave propagation in stratified media,** *Comm. pure appl. Math.* **4,** 1, 117–128, June 1951.

Author discusses reflection of electromagnetic waves incident on inhomogeneous layer of finite thickness in one-dimensional case. Reflection coefficients are determined on basis, essentially, of Liouville (or WKB) approximation. J. J. Gilvarry, USA

37. **Sekerzh-Zen'kovich, Ya. I., On the theory of standing waves of finite amplitude on the surface of a heavy liquid of finite depth** (in Russian), *Izv. Akad. Nauk. SSSR Ser. Geograf. Geofiz.* 15, 57–73, 1951.

In an earlier paper [AMR **1,** Rev. 586], author considered the problem of the title for water of infinite depth. The same method is applied in this paper for water of finite depth, and similar results are obtained. Lagrangian coordinates are used and the quantities of interest are expanded in a power series in a parameter ϵ, where $\epsilon = 0$ corresponds to the standing waves obtained by the linearized theory. The computations for the first three coefficients in the expansions are carried through in detail and the corresponding form of the free surface is given. For proof of the convergence of the series and of the uniqueness of the solution, reference is made to the method of the earlier paper. However, this paper was a brief note without proofs. There is no reference to recent work of R. Miche [*Ann. Ponts Chauss.* **114,** 25–78, 1944]. J. V. Wehausen USA

38. **Chertock, G., The response of a ball crusher gage,** *David W. Taylor Mod. Basin Rep.* 751, 9 pp., Apr. 1951.

A simple mathematical discussion of the equation of motion of the gage shows that it gives correct acceleration or peak pressure readings only if the form of the time variation of these quantities is shown in advance. Useful formulas for application to particular types of dynamic measurements are given. As it is assumed that the ball retains its maximum deformation, it is not the reviewer's opinion that the treatment is valid under conditions of rapid decay of stress. Jane M. Dewey, USA

39. **Logie, H. J., The velocity of seismic waves on the Witwatersrand,** *Bull. seism. Soc. Amer.* **41,** 2, 109–121, Apr. 1951.

Records of tremors from rockbursts in the Witwatersrand mining area near Johannesburg, South Africa, are investigated, using seven stations within about 15 km from Johannesburg which were equipped with special seismographs. On the average, about eight tremors occurred per day. Methods to determine the location of the sources and the depth (which was from 1 to $3\frac{1}{2}$ km) are discussed. Velocities of the waves in the sedimentary beds forming the upper and lower Witwatersrand system (using epicentral distances up to about 25 km) were found to be about 5.65 km/sec for longitudinal and 3.37 km/sec for transverse waves. Local variations are probable. These velocities "have been used successfully hundreds of times to find the focus of the disturbances." Calculated positions were in good agreement with available records of underground rockbursts. B. Gutenberg, USA

40. **Ricker, N., and Sorge, W. A., The primary seismic disturbance in shale,** *Bull. seism. Soc. Amer.* **41,** 3, 191–204, July 1951.

Paper describes experimental work carried out to obtain more exact knowledge of the laws of propagation of primary seismic disturbances. From a series of seismograms made in nearly homogeneous shale, authors determine velocity of propagation of dilatational part of disturbance and earth particle velocities. Law of decay of particle velocity in this shale is determined to be about $-5/2$ power of travel time. Variation in vertical velocity of propagation is shown as a function of depth.

Authors conclude experimental results are in good agreement with mathematical theory published by N. Ricker [title source, **33,** 197–228, 1943]. E. A. Ripperger, USA

41. **Press, F., Ewing, M., Crary, A. P., Katz, S., and Oliver J., Air-coupled flexural waves in floating ice,** *Geoph. Res. Pap., Air Force Res. Lab.* no. 6, 46 pp., 1950.

The authors made observations, on floating ice sheets, of flexural waves produced by explosions below, within, and above the ice. In the first two cases, the normal sequence of dispersive waves was found. In the last case, they observed only a train of waves of constant frequency corresponding to a phase velocity equal to the speed of sound in air, indicating strong coupling between the air and ice waves. Authors devise a mathematical theory in which the motions of the two fluids are governed by velocity potentials and the motion of the plate follows classical thin-plate theory, with appropriate boundry conditions at the interfaces. Solutions for a sinusoidal steady state and an exponential transient point source are then studied by methods previously employed by Lamb, Sezawa, Pekeris, and the authors themselves. Excellent agreement is found between theory and experiment. An appendix contains a suggestion for use of the theory to calculate the thickness of an ice sheet from measurements recorded at a distance. R. D. Mindlin, USA

42. **Press, F., and Ewing, M., Theory of air-coupled flexural waves,** *J. appl. Phys.* **22,** 7, 892–899, July 1951.

See preceding review.

Elasticity Theory

(See also Revs. 67, 115, 135, 283)

✉43. **Timoshenko, S., and Goodier, J. N., Theory of elasticity, 2nd ed.,** New York, Toronto, London; McGraw-Hill Book Co., Inc., July 1951, xviii + 506 pp. $9.50.

Preface is a clear statement of the objectives and an outline of the changes made in the second edition.

"The many developments and clarifications in the theory of elasticity and its applications which have occurred since the first edition was written are reflected in numerous additions and emendations in the present edition. The arrangement of the book remains the same for the most part.

"The treatments of the photoelastic method, two-dimensional problems in curvilinear coordinates, and thermal stress have been rewritten and enlarged into separate chapters which present many

methods and solutions not given in the former edition. An appendix on the method of finite differences and its applications, including the relaxation method, has been added. New articles and paragraphs incorporated in the other chapters deal with the theory of the strain gage rosette, gravity stresses, Saint-Venant's principle, the components of rotation, the reciprocal theorem, general solutions, the approximate character of the plane stress solutions, center of twist and center of shear, torsional stress concentration at fillets, the approximate treatment of slender (e.g., solid airfoil) sections in torsion and bending, and the circular cylinder with a band of pressure.

"Problems for the student have been added, covering the text as far as the end of the chapter on torsion."

Three-dimensional photoelasticity and the beginning of the complex variable approach for plane problems are included. In general, there has been a marked tightening up all along the line from the definition of plane stress and strain to the proof of the uniqueness theorem. The book has been made an even better compendium of existing useful information, and the excellent set of thought-provoking problems enhances its value. The only drawback from the pedagogical point of view is that elasticity is made to appear just a little too old and well-established. Many of the more general approaches and some of the newer developments which may be the main avenues for the future are barely mentioned or are omitted in favor of detailed solutions.

D. C. Drucker, USA

44. Bazant, Z., Nedoma, A., and Spála, K., Technical handbook, 3rd vol. Elasticity and strength theory [Nauka o pružnosti a pevnosti] 4th rev. ed., Prague, Česka Matice Technická, 1950, xii + 507 pp., 421 figs.

Book is predominately for use of engineers and students who are already acquainted with the subject.

After several introductory chapters dealing generally with internal forces, deformations and their relation, authors turn to the conditions of strength, looking also to the dynamical endurance limit and the shape of loaded bodies.

Subsequent chapters are devoted to considering straight rods, both statically determined and undetermined, and there is a detailed description of elementary kinds of stress, such as tension, compression, shear, torsion, bending and their combinations, accompanied by many examples.

There is, also, an extensive part dealing with strain-energy methods and dynamical effects. Impact tension and bending, stresses in rotating rims and arms due to centrifugal force and nonuniform rotation, stresses in a connecting rod due to inertia forces, longitudinal and transversal vibrations of straight rods, torsional and rotary vibrations of shafts and their critical speeds are the main content of this part.

Particular attention is paid to the stability of elastic systems. Several of the most interesting chapters of this part are on variable cross section, rods in an elastic medium, stability of curved bars and cylindrical tubes, stability of full-walled beams submitted to bending a.s.o. Special parts are devoted to curved bars and springs, stressed both in bending and torsion.

Subjects of next chapters are: cylindrical and spherical vessels with constant thickness of the wall; plates; rotating disks.

Final chapters deal with carrying walls, with the elastic hemispace (containing applications to the contact of spheres and rollers —Hertz's formulas), and include a short survey of plasticity. In this survey are found applications to pipes with high internal pressure, pressing of vessels of sheets, pressing in a cone matrix, torsion of cylinders of plastic materials, and bending of plastic beams.

Both the choice of subjects and the form in which they are given are well suited for the purpose, i.e., a reliable handbook for technicians who handle the very extensive field of elasticity and strength.

Vladimir Kopriva, Czechoslovakia

45. Bernabini, M., On the integration of the equations of plane elasticity in curvilinear coordinates (in Italian), *R. C. Accad. Sci. Fis. Mat. Soc. Naz. Sci., Lett. Arti Napoli* (4) 17, 1950 = *Cons. Naz. Ricer.* no. 292, 6 pp., 1951.

A theorem is demonstrated by means of which all the solutions of the equations of plane elastostatics are obtained; these equations are considered in a system of curvilinear orthogonal coordinates obtained by conformal transformation of the Cartesian plane.

From author's summary

46. Rathgeb, E., On the principle of virtual displacements and its application to elastic bodies (in Spanish), *Cienc. y Técn.* **116,** 586, 139–149, Apr. 1951.

Author has written a sound review article on the principle of virtual work and its applications to classical elasticity theory, designed for those members of the engineering profession having a modest background in applied mathematics.

A. W. Sáenz, USA

47. Föppl, O., The error of the existing considerations in the theory of elasticity (in German), *Schweiz. Arch.* **17,** 6, 171–177, June 1951.

Author points out that strains obtained by the separation of a stress system into one part of uniform hydrostatic tension and another equivalent to shearing stresses only are incompatible with continuity of body as a whole. The uniform expansions of each element are such that, except for constant hydrostatic tension throughout the body, individual elements in general cannot be brought in contact and form a continuous body without gaps. The same is true for individual elements deformed under the shear-stress system. It is suggested that any stress system be separated into a constant hydrostatic tension, a shear-stress system, and a "system of bending stresses" required to establish continuity by filling the gaps associated with the strains due to the other two stress systems. The "bending stress system" is, in general, twice statically indeterminate and may be computed by energy methods with the help of the displacements.

Significance of the theory is discussed in cases of a pipe with cap and pure bending of a beam, but no solution for the "bending stress system" is given. Reviewer notes that superposition principle of strains is established in linear theory of elasticity by neglecting higher-order terms in awareness that strict continuity conditions are violated. But in finite deformation theory, requirement of continuity is exactly satisfied. In the latter case, exact solutions are, in general, intractable but paper does not help in this direction. Hence, title of paper is misleading. Author has an interesting physical approach, however, that may lead to approximate solutions for deformations large enough to exclude use of linear theory but not of magnitude necessitating the use of exact theory. For the special cases of membranes and thin plates, such a procedure has already been established by A. Föppl and Th. von Kármán in their large deflection theories, where the requirement of continuity is applied to nonlinear approximate expressions for the strains.

George A. Zizicas, USA

48. Timpe, A., Stress functions of axisymmetrical deformation in cylindrical coordinates (in German), *Z. angew. Math. Mech.* **31,** 7, 220–224, July 1951.

The problem of the torsion-free axisymmetric deformation of bodies of revolution has been treated previously by the author by means of a single biharmonic function F [AMR **3,** Rev. 847].

In the first part of this paper author rederives the equations

expressing the displacement and the stresses in terms of F in polar coordinates, a well-known result [A.E.H. Love, "Mathematical theory of elasticity," New York, Dover, 1944, sec. 188] which is deduced in a rather novel manner. In the second part, author solves several typical problems of plate deformation by specializing the function F to polynomials of various degrees.

Albert W. Sáenz, USA

49. **Prager, W., The extremum principles of the mathematical theory of elasticity and their use in stress analysis,** *Univ. Wash. Engng. Exp. Sta. Bull.* no. 119, 29 pp., 1951.

A complete and clear development of the adaptation of function stress-space theory to problems of elasticity is presented. A stress space is defined, in which the square of the distance from the origin to any point S equals the strain energy associated with the state of stress represented by S. The number of dimensions of this stress space vary with the problem considered; i.e., a framework of n members requires n dimensions, and the problems of elastic continuum require an infinite number. Three states of stress are defined in the stress space; namely, the equilibrium state, the residual state (induced by satisfying the equilibrium conditions in the absence of external forces), and the compatible state. Using these concepts, author proves, by means of geometrical reasoning, several basic statements and theorems concerning the strain energy in an elastic body. The use of these allows the development of one approximate and two exact methods of stress analysis for elastic structures. The two exact solutions are used for structures of lower degree of redundancy. Illustrations of the three methods are presented.

Extension of the stress space permits solution of problems of elasticity with either stress or displacement boundary conditions, examples of both being treated. Further application of the geometrical interpretation of the stress space is made to other problems of mathematical physics, using as an example Dirichlet's problem for Laplace's equation in two dimensions. A method of determining bounds for the stress and strain components at an interior point of an elastic solid is also developed.

Robert E. Heninger, USA

50. **Horvay, G., Transient thermal stresses in circular disks,** *Gen. Electr. Knolls Atom. Power Lab.* KAPL-512, 101 pp., Aug. 1951.

Author determines the stresses and displacements for the technically important case of plane strain in a circular disk subjected to various temperature distributions. The physical parameters of elasticity and the coefficient of expansion are assumed to be constant. First, he considers stresses corresponding to a steady temperature proportional to $r^k \cos n\phi$. The radius of the circle is r; k and n are integers; and ϕ is the angular displacement of a radius from some reference line. Next, he considers the case of the initial temperature of the disk constant and the edge temperature given by $T \cos n\phi$, where T is constant and n and ϕ have the same definition as previously. The standard heat-conduction problem is solved so that the temperature in the disk is given as a function of time. The conclusion is that the solutions for stress in the steady-state case are of a form to be used in determining the stress corresponding to any time t for the time variable case. In particular, author finds that just after the time $t = 0$ the radial stress and shear stress are zero, but the tangential stress at the rim is $\alpha ET \cos n\phi$. This case he calls "thermal shock." Numerical data are given in the form of curves, but because they are on fine coordinate paper are exceedingly difficult to read.

Reviewer questions author's use of the label "transient stress" as well as his use of the designation "thermal shock." Author really solves a steady-state strain problem and, independently, a heat-conduction problem. Then, with temperature distribution corresponding to a particular time, he finds he can use the equations giving the stress in the steady-state case. It is clear that a time-variable temperature field involves inertia stresses arising from the acceleration terms in the equations of motion of elasticity. The equations must be solved simultaneously with the heat-conduction equation. A problem of this type was given in recent Russian literature [AMR **4**, Rev. 2835]. It is manifest that if in the "transient" case the rim temperature jumps to a value T instantly and the remaining disk is at the original constant temperature, the corresponding displacements occur in infinitesimal time, indicating large acceleration of the material at the rim of the disk. Furthermore, it appears that a complete theory of the phenomenon must also take into account velocity of the thermal front as it moves inward into the disk. Before these considerations can be ignored, proof is required.

W. H. Hoppmann, II, USA

51. **Ĕĭdus, D. M., On a mixed problem of the theory of elasticity** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **76,** 2, 181–184, Jan. 1951.

With reference to earlier papers of Michlin, Sobolev, and Friedrichs, author derives in vectorial form any conditions for general solution of stresses and strains in a body having its surface composed of several different parts.

Z. Bažant, Czechoslovakia

52. **Pomey, J., Abel, L., and Yenin, P., Determination of residual stresses in a hardened cylinder from case-hardened steel** (in French), *C. R. Acad. Sci. Paris* **232,** 18, 1641–1643, Apr. 1951 = *Génie civ.* **78,** 12, 229–231, June 1951.

Residual stresses were determined in a cylindrical test bar of chromium-nickel steel, with a diameter of 58 mm. The test bar was case-hardened to obtain a cementitic structure about 1 mm deep, and then hardened in a bath at 225 C. Experiments show that the residual stresses induced by the metallurgical transformations in the core of the test bar, when no case-hardening takes place, are small. However, the stresses in the case-hardened outer layer, which at 225 C remains austenitic, reach about 42 kg/mm². On these stresses are superimposed compressive stresses, which arise through the expansion of the case-hardened outer layer during the transition from the austenitic to the martensitic state. Thus, after hardening, a total compressive stress of about 140 kg/mm² is obtained in the case-hardened outer layer.

E. Siebel, Germany

Experimental Stress Analysis

53. **Durelli, A. J., and Lake, R. L., Some unorthodox procedures in photoelasticity,** *Proc. Soc. exp. Stress Anal.* **9,** 1, 97–122, 1951.

Paper describes the diffusion polariscope used by authors. The advantages in simplicity and ease of alignment are discussed along with the precautions necessary to eliminate boundary shadows. Photographs are presented to show fringe resolution of 0.005 in. or better. Next, authors describe a technique for using viscoelastic materials such as Catalin and BT-48-306 for two- and three-dimensional photoelastic tests. These materials exhibit creep and relaxation optical effects which depend only on time and not stress. Hence, as long as the models have regions of known stress or have calibration parts built into them, the stress distributions can be determined.

Reviewer is quite enthusiastic about the diffusion polariscope, since it is rugged and simple and eliminates the need for polished models; but he is not very optimistic about the use of the visco-

elastic materials, especially in regard to their use in simulated "freezing and slicing" three-dimensional tests.

M. M. Leven, USA

54. Barnhart, K. E., Jr., Hale, A. L., and Meriam, J. L., Stresses in rotating disks due to noncentral holes, *Proc. Soc. exp. Stress Anal.* **9,** 1, 35–52, 1951.

Stresses are studied by photoelasticity using Fosterite with frozen stress technique. Results are given for single noncentral holes and holes spaced symmetrically around the central hole. These are in reasonable agreement with approximate theory. Stress-concentration factors are given. Fosterite is shown to be free from time-edge effects, being less than $^1/_2$ fringe in error after two months. Previously "frozen" disk may be refrozen to give results for new conditions. R. N. Arnold, Scotland

55. Weaver, P. R., An optical strain age for use at elevated temperatures, *Proc. Soc. exp. Stress Anal.* **9,** 1, 159–162, 1951.

Author describes $^1/_2$-in. gage-length modification of the Tuckerman optical gage for use with the Tuckerman autocollimator. This gage is for use up to 500 F. A brief description of the optical system is included. Room temperature calibrations are given together with formula for determining factor at elevated temperature. Two examples of use of gage are presented. Author states that further development toward higher temperature range is being carried out. A. E. McPherson, USA

56. Troke, R. W., The direct-reading d-c strain gage bridge, *Instruments* **24,** 4, 5; 400–401, 450–458, 535–544; Apr., May 1951.

Paper is a comprehensive presentation of the theory and the techniques of application of resistance-wire strain gages as used with d-c bridge circuits. Discussion describes the various types of bridges and their applications, methods of calibration, and practical considerations. Morris Macovsky, USA

57. Gorton, R. E., Development and use of high-temperature strain gages, *Proc. Soc. exp. Stress Anal.* 9, 1, 163–176, 1951.

Paper is a further valuable contribution to the development and use of high-temperature wire strain gages for measurement of vibratory strains. Author describes in rather fine detail the construction, installation, and calibration of these gages.

Desirable features of these gages are: Linearity of output with strain amplitude, compact size, and low electrical leakage; gage factor varied linearly by about 16% between room temperature and 1550° F; the accuracy desired was about 10% for a range from about 35 microinches to strains equivalent to alternating stresses of ±15,000 psi in common turbine blade materials. It is not reported if this accuracy and sensitivity were achieved.

One principal undesirable feature is that these gages may not be stored for any length of time, ready for any application. Thus, up to the present time, anyone desiring to use such gages will have to construct their own. Yoh-Han Pao, USA

58. Buckley, W. H., and Anderson, R. G., Resistance wire strain gages in product developments, *Proc. Soc. exp. Stress Anal.* **9,** 1, 177–190, 1951.

Paper illustrates quantitative stress analysis by means of electric strain gages as a practical and quick method in the development of a product of complex structure.

Structural integrity of an automotive piston is investigated by simulating complicated loads on the piston by a series of simple static tests approximating thermal, gas-pressure, inertia, and residual stresses. As a preliminary step, various methods of mounting strain gages, both paper and bakelite, are investigated for stability under varying temperatures, humidity, and length of time.

Strain-gage stability tests indicated that gage null balance drifted with time immediately after bonding over a test period of 33 days under constant climatic conditions. Paper gages cured at room temperature for 24 hr and covered with cerese wax produced the least drift. Bakelite gages, properly bonded and utilizing a temperature-compensating gage, yielded satisfactory results. All gage samples demonstrated unsatisfactory stability under high humidity, indicating importance of controlling humidity during long test periods. Gage resistance to ground was found to be a rough measure of gage stability.

When measuring thermal stresses, null balance drift was reduced materially by temperature cycling at least once and making drift measurements when test part was on cooling leg of heat cycle. Length of lead wire and solder connections affected null balance at elevated temperatures, and effect was calibrated. Residual stresses were determined by sectionalizing piston skirt and measuring change in stresses.

Analysis indicated importance of side forces and thermal stresses on piston design. Endurance tests verified step-by-step load approximations in static tests.

Reviewer believes authors have made a thorough and practical analysis of the stresses in an automotive piston. The method can be extended to other cases. Maurice A. Walter, USA

59. Milbradt, K. P., Ring-method determination of residual stresses, *Proc. Soc. exp. Stress Anal.* **9,** 1, 63–74, 1951.

Ring method consists of noting strain readings on gages placed in a scribed circle after drilling central hole and after cutting isolated ring. Biaxial stress solutions and two examples are given. Advantage similar to trepanning method is claimed for ring method, but hole provides guide for easier cutting of disk.

Henry A. Lepper, Jr., USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 27, 29, 91, 93, 314)

60. Vedeler, G., Basic function for beams with arbitrary constraint, *K. norske Vidensk. selsk. Förh., Trondheim* **22,** 37, 171–177, 1950.

The deflection of a beam with elastically constrained ends is expressed in terms of the eigenfunctions associated with the beam oscillations. A table and a graph illustrate the eigenfunctions associated with various degrees of constraint.

G. F. Carrier, USA

61. Brice, L. P., Stress measurements in a cross section in bending of a reinforced concrete beam (in French), *Publ. int. Assn. Bridge Struct. Engng.* **10,** 1–9, Nov. 1950.

An attempt is made to investigate, in one single test, the actual stress (rather than strain) distribution in a reinforced-concrete beam. The concrete at midspan of a third-point loaded beam is replaced by eight square steel rods, vertically arranged and suitably anchored. The arrangement occupies more than one third of the middle third of the beam. Strain gages are placed on these rods as well as on the two reinforcing bars. Strains in these rods were linear up to the largest test load, 85% of the ultimate, and the location of the neutral axis was constant and independent of load. Steel stresses in the two reinforcing bars, one above the other, deviated considerably from linear distribution, which author explains by excessive slip of the plain, hooked bars.

Reviewer believes that stresses so obtained are not representative of real concrete stresses, since test device substantially affects

behavior of specimen in that a linearly elastic material of different stiffness is used to replace concrete with nonlinear stress-strain behavior over a considerable length, and measurements are made on this elastic material. The conclusion that seems valid is that steel stresses in plain, hooked bars may deviate substantially from computed values on account of slip. This agrees with the much more extensive evidence presented by R. M. Mains, "Measurements of the distribution of tensile and bond stresses along reinforcing bars," accepted for early publication in *J. Amer. Concr. Inst.* George Winter, USA

62. **Remta, F., Calculation of the cable of a cableway** (in Czech), *Strojírenství* **1**, 9, 329–335, Sept. 1951.

Emphasis is placed on correct and exact determination of stresses in all cross sections of the cables during operation of cable tramways. The following kinds of stresses and stress components are thoroughly investigated and discussed: (1) Stresses due to dead load components; (2) stresses due to resistance during operation, and to friction and stiffness of cables; (3) stresses due to gravity forces, especially at start and stop (resistance to the motion); (4) initial stresses due to balancing counterweights at one terminal; (5) stresses due to bending over power drums and grip wheels. Exact and approximate methods of calculating these stresses are explained and demonstrated by a numerical example. References are made to the following authors: Hanfstengel, Dukelskij, Stephan, Rubin, and Remtpa.

J. J. Polivka, USA

63. **Kohler, K., Error limitations of the sag calculation of transmission lines** (in German), *Bull. Assn. suisse Elect.* **42**, 9, 303–306, May 1951.

For the sag determination of transmission lines, instead of the catenary, as an approximation, a parabolic form of the wire is generally used because of calculation facilities. In this paper the error of the sag obtained by this approximation is thoroughly discussed, with the conclusion that for accuracy of 1%, generally realized in the execution of such works, the parabolic form can be adopted. Aurel A. Beleș, Rumania

64. **Capra, V., On a particular series which occurs in a problem of science of structure** (in Italian), *Atti Accad. Sci. Torino* 84, 1, 181–188, 1949–1950.

In a study of the elasticoviscous conditions of a beam in unstable equilibrium, the differential equation

$$u_{zzt} + u_t P/EI + (Qz/2 + Pu)\bar{\epsilon}'_0/I = 0$$

proposed by F. Levi [AMR **4**, Rev. 634] is considered. This paper deals with the condition of convergency of the series which solves the differential equation and gives a recurrent method of determining the serial coefficients.

Maria Castellani, USA

65. **Eriksen, B., Beams with variable moment of inertia,** *Concr. Constr. Engng.* **46**, 6, 7; 177–181, 207–214; June, July 1951.

Method of calculating bending moments, using tabulated numerical values, is presented for classes of continuous or restrained haunched beams. Method utilizes knowledge of points of zero deflection [title source, **43**, 1, 2, 3; 3–8, 47–52, 78–87; Jan., Feb., March 1948]. Detailed example for finding influence lines and shear and bending moment diagrams is given for a continuous-girder bridge. Designers of haunched structural members should find method useful and time saving.

C. M. Tyler, Jr., USA

Plates, Disks, Shells, Membranes

(See also Revs. 50, 54, 78, 95)

66. **Korenev, B. G., On the deflection of an infinite plate on elastic foundation** (in Russian), *Dokladi Akad. Nauk. SSSR (N.S.)* **78**, 3, 417–420, May 1951.

Paper deals with a whole class of important problems on deflection of an infinite plate with constant thickness and on elastic foundation.

Author uses the well-known method of influence functions and of Fourier integrals to solve his problems. He shows significance, construction, and application of the kernels of some important plate problems.

The most important results are solutions for new models of elastic foundation and for special types of loading (over different parts of the circle, for instance). Author introduces further certain new kernels, each depending on two parameters, with the aid of which one can approximate real conditions occurring in technical practice.

Paper, perhaps a little difficult from mathematical point of view, is of considerable theoretical and practical value. Reviewer recommends it to engineers and physicists.

V. Vodicka, Czechoslovakia

67. **Nelson, C. W., A Fourier integral solution for the plane-stress problem of a circular ring with concentrated radial loads,** *J. appl. Mech.* **18**, 2, 173–182, June 1951.

A limited extension of a Fourier integral solution to the case of concentrated loads acting on curved bars. Approach is made to the problem by deriving a stress function to satisfy boundary conditions. Although the method is tedious, tabulation and the use of approximate methods tend to minimize this deficiency.

Clarence B. Matthews, USA

68. **Zerna, W., Membrane theory of generalized shells of revolution** (in German), *Ing.-Arch.* **19**, 3, 228–230, 1951.

Author follows procedure outlined previously in his dissertational treatise [AMR **3**, Rev. 2213] in which he developed in rectangular coordinates the basic equations of a shell having the form of a surface of revolution.

In this paper the problem of stresses in a shell with a special class of surface of revolution is solved through vectorial representation. The general surface is conical with a straight line as generator. Three equations of equilibrium are derived, then are reduced to one single differential equation of second order, which is the characteristic equation of the problem. When the normal forces on the boundary are known, this characteristic equation may be solved without difficulty with the aid of any approximate method. Thus the problem of a shell having the form of a surface of revolution is solved directly without use of stress function.

Wilhelm Ornstein, USA

69. **Day, J. W., Hydrostatic pressure tests on thin rectangular diaphragms 21 inches by 13$^1/_2$ inches,** *David W. Taylor Mod. Basin Rep.* 635, 42 pp., Mar. 1951.

Paper describes pilot tests on small rectangular diaphragms made primarily for the purpose of developing experimental techniques to be used in testing larger diaphragms. Sample results of tests to failure of plain, laminated, and reinforced diaphragms are given, and deflections and energy absorption are compared with those indicated by theory. It is shown that, from a pressure-deflection curve of any model diaphragm, the plastic deflection and energy absorption of any circular or rectangular diaphragm can be predicted approximately. R. J. Roark, USA

70. Giovannozzi, R., and Ricci, L., Tables for calculation of thermal and centrifugal stresses in conical disks or disks decomposable in partial conical trunks, I, II (in Italian), *Aerotecnica* **31**, 3, 159–168, June 1951.

The detailed numerical tables are based on Honegger's theory of centrifugal stresses in conical disks. A modification is suggested to allow using the same tables for disks of constant thickness. For thermal stresses, reference is made to the theory and numerical tables of a previous paper by the first author [AMR **4**, Rev. 3510]. For arbitrarily variable thickness, the decomposition in partial trunks proposed in the mentioned paper reduces the problem to numerical calculations with the help of the tables. A tabular form for convenient computation is presented and applied to two examples. George A. Zizicas, USA

71. Levi, F., Influence surfaces and phenomena of adaptation in plates (in Italian), *Atti Accad. Sci. Torino* **84**, 1, 86–93, 1949–1950.

Author assumes that in some part of a plane plate there is an inelastic deformation besides the elastic one. The differential equation of plate bending is rewritten for this case. He suggests applying it to the computation of influence functions, representing their singularities by such local inelastic deformations. No analytical solution is offered, but the reader is referred to the Marcus network method. W. Flügge, USA

72. Ericksen, W. S., Deflection under uniform load of sandwich panels having facings of unequal thickness, *For. Prod. Lab. Rep.* 1583-C, 32 pp., 3 figs., Dec. 1950.

A method for determining the deflection of a sandwich panel under normal uniform load is worked out. The sandwich plate considered is assumed to have orthotropic core and facing materials and different thicknesses for the two facings. Two edge conditions are considered, namely, all edges simply supported and all edges clamped. C. T. Wang, USA

73. Floor, W. K. G., Experimental investigation of the post-buckling behaviour of flat, rectangular plates under combined shear and compression, Part III, *Nat. LuchtLab. Amsterdam Rap.* S. 367, 12 pp., Apr. 1950.

Report is concerned with the method of data reduction employed on test results of flat rectangular plates under combined shear and compression. Author discusses the effects of correction factors due to hinge friction in the loading frame, etc., on the test results as compared with theoretically computed values. In the opinion of the reviewer, this report is of questionable value without the references upon which it is based. In addition, the translation is poor and often misleading. Norman Grossman, USA

74. Kalmanok, A. S., Structural mechanics of plates [Stroitel'naya mekhanika plastinok], Moscow, Mashstroiizdat, 1950, 303 pp. s2.

The first chapter is devoted to development of statical and deformation relations for thin plates in rectangular coordinates. Author reduces plate problem to solution of two fundamental equations. The first of these is homogeneous biharmonic: $\nabla^2\nabla^2 F = 0$, in which $N_x = \partial^2 F/\partial y^2$, $N_y = \partial^2 F/\partial x^2$, and $T_{xy} = -\partial^2 F/\partial x \partial y$. N_x and N_y are normal forces per unit length and T_{xy} is shearing force per unit length of plate. The second fundamental equation is the nonhomogeneous biharmonic:

$$D\nabla^2\nabla^2 w = q(x, y) + (\partial^2 F/\partial y^2)(\partial^2 w/\partial x^2) + (\partial^2 F/\partial x^2)(\partial^2 w/\partial y^2) - 2(\partial^2 F/\partial x \partial y)(\partial^2 w/\partial x \partial y)$$

D being the usual flexural rigidity for plates, and w the deflection. For stability problems, the same equation is used with $q(x, y) = 0$.

Three methods are available for solving fundamental equations. First method, using complex variables, yields:

$$F(x, y) = Re[\bar{z}\varphi(z) + \chi(z)]; \quad \bar{z} = x - iy$$

Stress and strain components can be expressed by two analytic functions. This approach gives easy solutions for circular plates. For other shapes, conformal mapping on circle can be used. Solutions can be represented by series or reduced to integral equations. (Circular plates are not treated in book.)

The second method is that of finite differences which Marcus uses in his book "Theorie Elastischer Gewebe." This method has the disadvantage that solutions are not in analytic form.

The third method, which author uses, is trigonometric series of Fourier. Solution for deflection takes the following form:

$$Dw(x, y) = Dw_1(x, y) + \Sigma_n f_n(x) \sin(n\pi y/b) + \Sigma_n f_m(y) \sin(m\pi x/a) + P(x, y)$$

$Dw_1(x, y)$ is particular integral of biharmonic equation, Σ terms are solutions of homogeneous biharmonic, and $P(x, y) = a_{ij}x^i y^j$, $(i = j = 0, 1, 2, 3)$ algebraic polynomial of 12 possible terms. $P(x, y)$ is used to satisfy boundary conditions where trigonometric series are inadequate—as at corners.

Author uses superposition to solve plate problems. Infinite strip is the basic system to which given and special loadings are applied. Special loading solutions superposed on given loading solutions result in the solution of the given problem. The idea is similar to finding the forces and moments applied to an infinite beam on elastic foundation and so adjusted that results superposed on corresponding results, due to actual loading on infinite beam, yield the solution to a finite beam. Author succeeds in solving numerous rectangular plate problems heretofore intractable or, at best, unwieldy.

Tables of certain functions are given at end of book to expedite work in practical application. S. Sergev, USA

Buckling Problems

(See also Revs. 73, 102)

75. Szécsi, A., Eccentric buckling. Application of theory of plasticity (in French), *Bull. tech. Suisse Rom.* **77**, 10, 133–141, May 1951).

Author presents a powerful, quickly converging method for calculating plastic collapse loads of eccentrically loaded columns. Theory is developed as far as possible in terms of a general cross section, and is applied to examples of rectangular section. Results agree well with tests in symmetrical single curvature, but tests are not quoted for the case of asymmetrical double curvature, and reviewer considers that theory may not give equally good correlation for such cases. Jacques Heyman, England

76. Hoff, N. J., Nardo, S. V., and Erickson, B., An experimental investigation of the process of buckling of columns, *Proc. Soc. exp. Stress Anal.* **9**, 1, 201–208, 1951.

Paper is report on experiments which clarify phenomena occurring when a column buckles. Tests were made on 34 columns of 24S-T aluminum alloy, and complete evaluation was made for ten specimens.

Strain measurements were taken with SR-4 gages cemented on opposite sides of the columns and data collected for (a) strain on side of column at the midpoint; (b) total load supported by the column; (c) displacement of loading head. Test results presented are photographs of oscilloscope beam showing stages during the buckling of (1) an elastic column; (2) an inelastic column.

Results of tests indicate that during elastic buckling, (a) the loading head descends at uniform rate; (b) the strain on the concave side changes more rapidly than that on convex side; (c) the load supported remains constant. For inelastic buckling, (a) the load supported suddenly drops; (b) the loading head is suddenly displaced; (c) the stresses on both sides suddenly change by about the same amount; and (d) the displacements at buckling occur in approximately $^1/_{50}$ sec. D. E. Hardenbergh, USA

77. **Schnadel, G., Buckling of ship plates,** *David W. Taylor Mod. Basin Transl.* 66, 25 pp., Sept. 1950.

78. **Federhofer, K., On the calculation of cylindrical tanks with variable wall thickness** (in German), *Anz. Akad. Wiss. Wien* 87, 275–287, 1950.

Circular cylindrical shell, considered as a tank filled with liquid, previously had exact solutions only for constant shell thickness or linear variation in thickness ["Theory of plates and shells," by Timoshenko]. Author presents a third case in which thickness of tank wall increases parabolically with depth. For nonuniform wall thickness, solution of problem requires integration of linear differential equation of fourth order with variable coefficients. Author shows that problem can be reduced to two similar second-order homogeneous linear differential equations if the wall thickness is a quadratic function of the axial coordinate. For this special case, general solution is obtained in closed form by means of elementary functions. The four constants of integration are left to be evaluated from the boundary conditions in practical calculations. Harold Lurie, USA

79. **Norzi, L., Buckling loads for latticed struts with battens only** (in Italian), *Atti Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. Nat.* (8) **10,** 3, 217–219, Mar. 1951.

A new formula for the critical load is derived under the assumption of antisymmetrical deformation of the vertical channels and of uniformly distributed battens. The critical value approaches Euler's critical load for the two separate channels when the moment of inertia of the battens approaches zero, and approaches the Euler load for a column when the moment of inertia of the batten nears infinity. This asymptotic approach is not obtained in the expression of Eq. 95 of Timoshenko's "Theory of elastic stability." Mario G. Salvadori, USA

Joints and Joining Methods

80. **Begeman, M. L., McBee, F. W., Jr., and Fontana, J. C., The physical and metallurgical characteristics of spot-welded titanium,** *Weld. Res. Suppl.* **16,** 9, 429s–434s, Sept. 1951.

A study was made of the properties and problems of spot welding commercially pure titanium (Ti-75A in 22-, 24-, and 25-gage). The major variables were weld current, weld time, and electrode-tip pressure. Optimum welding conditions were established. Strength tests were made on a $^3/_4$-in. lap; plug failures resulted. Weld strength was found to (1) increase quite uniformly with increase in current up to 16,240 amp, then decrease gradually; (2) increase to a maximum as the weld time was increased to 12 cycles—additional time had no appreciable effect. Penetration was high and was affected only slightly by current changes and/or weld-time changes. Tip pressure had little or no effect on strength in the range of 100 to 1000 lb. Hardness surveys, tip-life tests, and observations on indentation, flashing, and metal expulsion were also made. A comparison between spot welding of titanium and low-carbon steel indicated that although the weld time is about the same, approximately 50% greater current is required in welding titanium, and that 25 to 50% greater tip pressure is required for best results. Carl E. Hartbower, USA

81. **Borchard, B., Developments in nailed structures during the past 10 years** (in German), *Bautechnik* **28,** 7, 145–147, July 1951.

Reference is made to both plain-shank and twisted-shank nails and to steel and aluminum-alloy nails.

Dynamic tests indicate that nails both in single and double shear fail at several places along the nail shank without appreciable shank deformation under dynamic load applications. Hence, only extremely small design loads should be applied if the structure is dynamically loaded.

According to previously unpublished test information, the strength of nailed joints is the same whether the plain-shank nails are driven from one side or alternatively from both sides.

Outstanding examples of recently erected nailed structures are presented, including a 250-ft high, $4^1/_2$-ft square column and a combination of a two-hinged and three-hinged arched roof structure consisting of nailed beech boards. E. G. Stern, USA

82. **Dean, R. B., Waterproof adhesives for cellulose,** *J. Colloid Sci.* **6,** 4, 348–353, Aug. 1951.

To satisfy the tests of the Douglas Fir Plywood Association (D.F.P.A.), the glue line in a waterproof plywood must show at least 90% adhesion after two 4-hr periods in boiling water separated by a 20-hr drying period at 35 C.

From author's summary

Structures

(See also Revs. 49, 61, 121)

83. **Steinbacher, F. R., Gaylord, C. N., and Rey, W. K., Method for analyzing indeterminate structures stressed above proportional limit,** *Nat. adv. Comm. Aero. tech. Note* 2376, 47 pp., June 1951.

Numerical successive approximation method is presented for pin-ended structures with straight members. Any solution treating the structure as elastic provides geometrically compatible strains for the members. From these strains and stress-strain diagram, actual external loading can be calculated. Thus, to every elastic solution based on strains due to a fictitious elastic loading there corresponds an actual nonelastic loading. In general this fictitious loading will differ from actual loading in both magnitude and direction.

Method is to find fictitious elastic loading corresponding to applied actual loading. This is done by assuming an elastic loading and then calculating corresponding strains and actual loading. As this calculated actual loading will not usually equal applied loading, successive corrections are made to fictitious elastic loading until corresponding actual loading equals applied loading.

Two examples of three-bar coplanar structures are worked in detail. Calculated loads check experimental measurements generally within 2%. C. M. Tyler, Jr., USA

84. **Assinare, J., Comparative study of a statically indeterminate portico by different methods using models** (in French), *Labor. Bât. Trav. publics, C. R. Rech.* **14,** 10 pp., 2^d Sem. 1950 = *Cah. Centre Scient. Techn. du Bâtiment* no. 8, cahier 85.

Purpose of test was to compare accuracy of certain methods of experimental stress analysis of plane continuous frames by means of models. In particular, the accuracy of direct methods, in which the actual loads are applied and the points of zero moment

are located, is compared with that of indirect methods which yield influence lines by means of displacement measurements. Tests were made on a shed-type portal frame with feet pinned in one case, clamped in the other. The two direct methods used were those of photoelasticity (Plexiglas model) and of direct measurement of curvature (steel model). Begg's deformeter was the indirect method used for comparison. Some of the common difficulties encountered are discussed, and typical errors of the various methods are compared. P. S. Symonds, USA

85. Torroja, E., Elementary lessons on elasticity with applications in structural design [Lecciones elementares de elasticidad con aplicacion a la técnica de la construccion] 2nd ed. (in Spanish), Madrid, Editorial Dossat, 1951, xvi + 310 pp.

This basic textbook on structural applications of the theory of elasticity in Spain and Latin-American countries is written by one of the leading structural engineers who is internationally known in connection with unusual shell-type structures and long-span arch bridges in reinforced concrete. In the first part, general problems of three-dimensional stress analysis are presented; second part contains two-dimensional stress problems; and the third part is devoted to structural problems frequently encountered in engineering practice. Methods of experimental stress analysis, especially photoelasticity, are presented, but in condensed form.
J. J. Polivka, USA

86. Scott, M. B., A further study of the behavior of floor-beam hangers, *Bull. Amer. Rly. Engng. Assn.* **53,** 495, 35–63, June-July 1951.

This third paper of a series describes and analyzes a static test on a floor-beam hanger in a 124-ft pin-connected through truss. The hanger consisted of two channels with lacing throughout most of the free length. SR-4 strain gages were used to determine the distribution of static stress and, thus, moment and shear at 12 sections along the member. No dynamic strains were measured. Stress concentrations at coped flanges were also measured.

The lacing was effective in making the channels act as a unit. The deflection of the floor beam set up bending stresses as high as 64% of the average axial stress. The shearing deflections in the hanger were large enough to be significant in the analysis. The shear slope in the floor-beam diaphragm and the misfit of the pins must be included in the analysis in order to account for the measured stresses. Stress-concentration factors as high as 5.7 were observed in the sharp re-entrant cuts in the coped flanges.
Marshall Holt, USA

87. Barwell, F. T., Sandwich construction and core materials, Part IV. Notes on some methods of testing core materials, *Aero. Res. Counc. Lond. Rep. Mem.* 2467, 17 pp., May 1946, published 1951.

Factors which must be taken into account in testing low-density core materials are discussed. For the determination of modulus in compression and shear of core materials, a technique involving the repeated application and removal of a definite load is suggested, and this is found to yield more definite results than a conventional determination of stress-strain curve. Modulus of shear may be determined from either a tubular specimen under torsion or a double shear test of rectangular specimen. A suggested order of tests is presented to eliminate unpromising materials with a minimum of experimental work. A hypothetical material composed of solid laminae of uniform thickness disposed in mutually perpendicular planes with uniform separation is treated analytically to illustrate the basic difference between core materials and the usual homogeneous isotropic materials.
Conrad C. Wan, USA

88. Lewis, S. R., The evaluation of matrix elements for the analysis of swept-back wing structures by the method of oblique coordinates, *Coll. Aero. Cranfield Rep.* 44, 9 pp., Apr. 1951.

Report is essentially an appendix to previous Report 31 [see AMR **3,** Rev. 2207]. It contains carefully calculated tables and curves for the matrix elements used in the determination of stresses and strains by the methods described in Report 31. The range of parameters is sufficient for most aircraft problems. In order to facilitate preliminary investigations, approximate formulas are given for certain of the matrix elements.
Dana Young, USA

89. Fine, M., and Hopkins, H. G., Stress diffusion adjacent to gaps in the inter-spar skin of a stressed-skin wing, *Aero. Res. Counc. Lond. Rep. Mem.* 2618, 13 pp., May 1942, revised 1950, published 1951.

Beam considered has doubly symmetrical rectangular cross section with four corner flanges and webs, or walls, which carry normal as well as shearing stresses. Top skin has a chordwise gap from flange to flange ("chordwise gap" apparently means either a chordwise slit or a cut-out). Beam without gap is analyzed by ordinary beam theory. Effect of gap is obtained by adding a self-equilibrating stress system to cancel normal stresses at gap and add a force in the top flanges.

Neglect of shear lag in side walls reduces problem to the analysis of a two-stringer panel. Exact solution gives infinite shear flow at corners. Use of an approximate solution based on an "equivalent area" criterion reduces shear flow to finite value. The numerous approximations used to obtain a simple solution to this very important practical problem leave its accuracy open to question. Comparisons with experiment and with solution by more accurate methods such as those of Cicala [AMR **1,** Rev. 629] or Hadji-Argyris and Dunne [AMR **1,** Rev. 626], would be desirable. Stanley U. Benscoter, USA

90. Mason, A. H., Vibration characteristics of the Potomac River Bridge, *Bull. seism. Soc. Amer.* **41,** 3, 181–190, July 1951.

Transverse and vertical motions of the bridge, and transverse and longitudinal motions of the piers of this rigid frame structure under the vibratory excitation of the wind, traffic, waves, tidal action, and artillery fire were experimentally determined. Amplitudes and periods are presented in tables. Detailed analysis of the results relative to the design conditions is not discussed.
James W. Mar, USA

91. Ish-Horowicz M., The application of plastic theory to bending. An examination of the general principles involved in applying "limit design" to structural members, *Aircr. Engng.* **23,** 269, 203–206, July 1951.

This is a discussion of limit design theory as applied to determinate and indeterminate beams in bending. The behavior of various cross-sectional shapes is noted, as well as the effect of differences between the stress-strain curves in tension and in compression. A number of test results obtained by other authors are analyzed. Bruno A. Boley, USA

92. Heyman, J., The limit design of space frames, *J. appl. Mech.* **18,** 2, 157–162, June 1951.

A method is proposed for the limit design of space frames in which all members lie in the same plane, all loads acting perpendicular to this plane. An extension of the Greenberg-Prager maximum-minimum method for the limit design of plane frames is used. The latter method, to be presented in a forthcoming *Amer. Soc. civ. Engrs. Proceedings* separate ["On limit design of beams and frames," by H. Greenberg and W. Prager], is based upon the insertion of a suitable number of plastic hinges into

the structure, after which upper and lower bounds for the collapsing load may be determined. These bounds may be narrowed by a system of successive approximations, involving rational shifting of the hinges.

Author replaces the plane-frame breakdown criterion, based upon moment only, with a function of moment and torque. At a plastic hinge, von Mises' flow relations then establish a relation between rate of twist and rate of bending. Two simultaneous equations are thus obtained, which may be solved to give unique values of the plastic moment and torque.

Solution is then analogous to the Greenberg-Prager method as applied to plane frames, but somewhat more involved. The principle of virtual work applied to the rate at which work is done can be employed to simplify the analysis of the structure. A numerical example is worked in detail. Howard Simpson, USA

93. **Anonymous, Recent experiments on concrete beams reinforced with chrome-steel bars** (in German), *von Roll Mitteilungen* **10**, 1, 11 pp., March 1951.

Paper describes bending tests on three reinforced-concrete beams, reinforced with chrome steel, with yield between 52,500–61,000 psi. Tests confirm the fact that use of a number of small reinforcing bars distributed in tension zone, instead of a few large bars, reduces the number and size of cracks. Maximum crack width is related to factor V, equal to total area of steel divided by total circumference of rods. Frank A. Blakey, Australia

94. **Hempel, S., Beam in prestressed concrete with parabolic reinforcement** (in Polish), *Inżyn. Budown.* **8**, 4, 170–171, Apr. 1951.

Author derives the equation of the deformed axis of a beam subjected to prestress by a parabolic cable, taking into account the change of eccentricity caused by the deflection. The exact knowledge of the deformed axis is emphasized especially for research-work purposes and precise measurements.

W. Olszak, Poland

95. **Kuryllo, A., Diagram for the calculation of reinforced concrete plates** (in Polish), *Inżyn. Budown.* **8**, 4, 166–169, Apr. 1951.

Simple formula and diagram are presented for direct dimensioning simply supported and continuous reinforced-concrete plates, taking into account their so far unknown dead weight. The calculation of bending moments is unnecessary, the results depending directly on the (uniformly distributed) working and permanent loads $p_0 = p + s$ and the span of the plate (real l or fictitious l').

W. Olszak, Poland

96. **Rychner, G. A., Practical criterion for evaluation and reducing of cracking danger in reinforced concrete** (in German), *Schweiz. Bauztg.* **69**, 23, 24; 319–323, 338–341; June 1951.

Based on observations made at the Swiss Federal Institute for Testing Materials and on Swedish investigations, author has endeavored to establish a general theory of cracks. Theory presumes, very logically, that capacity of elongation of concrete is a material constant independent of reinforcement, and that width of cracks depends principally on state of adhesive stress. This state of stress in turn depends primarily on difference of tensile stresses in reinforcement in full uncracked section and in cracked section in instant of formation of cracks. Experiments confirm this difference, and therefore also width of cracks, to be inversely proportional to ratio of reinforcement and bonding strength, but proportional to tensile strength of concrete.

A simple formula is established, which permits judging danger of too wide cracking, valid for reinforced concrete submitted to bending, tension, and shear. Author concludes that cracking can be favorably influenced by increasing bonding strength of reinforcement, by making structural elements more slender, and by using small-diameter rods. This leads to use of high-bond steel and to vibration of concrete. As to shear reinforcement, author advocates abandoning bent-up rods and using only inclined or vertical stirrups. Eckhardt Rathgeb, Argentina

97. **Krebs, G., The transition curve in highway construction** (in German), *Bautechnik* **27, 28**; 6, 9; 176–179, 207–212; June 1950, Sept. 1951.

Author proposes substitution of classical transition curves by Cornu's spiral. This, also called clothoid, has its radius at each point, proportional to the reciprocal of arc length from origin. Mathematics is applied with rigor after some practical simplifications. Author emphasizes importance of change of rate of acceleration with respect to time, or second acceleration, in connection with arc development. Disadvantages of classical methods are cited, such as too short transition arches and indetermination of corresponding safety coefficient. Clothoid numerical tables are mentioned but not included. Six examples show practical applications: (1) General case; (2) minimal central angles; (3) highways crossing; (4) turning mountain roads; (5) transition arc between curves; and (6) opposite curvature cases.

Reviewer recognizes technical importance of such examples. Author remembers that his subject has been presented previously and separately by Schürba and Kaspar.

Jorge Carrizo Rueda, Argentina

98. **Ross, A. D., Tests of prestressed concrete beams with alloy steel bars,** *Mag. Concr. Res.* no. 7, 9–18, Aug. 1951.

Load-deflection curves of five beams of different design are given and discussed along with comparison between calculated and measured strains. Aim of paper is principally to obtain performance data rather than research material. Tabulation of results is well organized to refute standard objections to prestressed beams from noninitiated builders. Robert Quintal, Canada

99. **Seitz, H., Knee-braced purlins and their economical design** (in German), *Bautechnik* **28**, 7, 147–152, July 1951.

Comparison is made of five different designs for knee-braced purlins. Present German standard specifications (DIN 1052) require the use of 50 to 100% more lumber for these purlins than previous specifications, despite the fact that previous designs proved to be satisfactory for periods of 20 and 30 years.

While the knee-braced purlins are continuous beams over three spans, they should be designed as freely supported beams over the maximum span if the load essentially is uniformly distributed.

E. G. Stern, USA

100. **Hillerborg, A., Dynamic influences of smoothly running loads on simply supported girders,** *Kungl. tekn. Högskol. Stockholm*, 126 pp., 1951.

Author attempts to derive a theory for the dynamic behavior of bridges by moving a single load smoothly along a simply supported uniform section girder. Differential equations of motion are derived and methods of solution shown. The load distribution and the shape of the girder are presented as a series of orthogonal functions in which only the first term is used, and a step-by-step analysis is presented for their solution. A series solution leads to approximations which are far from exact, thereby preventing differentiations to obtain bending moments and shear forces. Author shows devices for circumventing this deficiency. Simple tests were designed and performed, the analysis of which showed relatively good correlation with theoretical data. Exten-

sive tables have been prepared to expedite the calculations. Reviewer believes author should be congratulated for presenting a very lucid and original paper. Clarence B. Matthews, USA

101. Wilkesman, F.-W., Loads on girders forming edges of simply supported plates under point-loads (concentrated forces) on the plate (in German), *Bautechnik* **28**, 6, 7; 76–80, 88–90; June, July 1951.

Paper investigates the distribution of the load along one edge of a rectangular simply supported plate, for concentrated loading. An exact solution is given in the form of a series for the following cases: (1) Plate simply supported at the four edges; (2) two-bay plate, continuous over a simple central support; (3) semi-infinite plate strip, simply supported along the parallel infinite edges and simply supported or built-in along the other (finite) edge.

Paper contains, also, numerical influence surfaces giving the total reaction of an edge, and proposes an approximate method for the calculation of this quantity. Ch. Massonnet, Belgium

102. Barrett, P. F., and Seide, P., An experimental determination of the critical bending moment of a box beam stiffened by posts, *Nat. adv. Comm. Aero. tech. Note* 2414, 9 pp., July 1951.

An experimental determination of the critical bending moment of a box beam stiffened by posts is described and discussed. The experimental buckling load is in good agreement with that given by theory. Since appreciable distortion of the beam cross section occurred before the buckling load was reached, modification of post construction by the use of several ribs may be necessary for maintenance of the rectangular shape of the cross section.

From authors' summary

103. Soldà, G., Influence lines with regard to bending moments in ships (in French), *Bull Assn. tech. marit. aéro.* no. 49, 569–586, 1950.

Writer develops a series of equations from which the influence lines for longitudinal moment may be computed. First development is for a ship in still water, and then, by considering geometrical relations, these equations are modified for a condition of hogging or of sagging. Three algebraic examples are given for value of moment at midships for different geometric conditions, modifications of a ship which has a midship section approximately rectangular. Cameron M. Smith, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 71, 92, 144, 146, 151, 291)

104. Bishop, J. F. W., and Hill, R., A theory of the plastic distortion of a polycrystalline aggregate under combined stresses, *Phil. Mag.* (7), **42**, 327, 414–427, Apr. 1951.

Paper states a general relationship between stress and plastic strain in a polycrystalline aggregate, derived for any metal in which individual crystals deform by slipping over preferred planes under a critical shear stress. Full account is taken of the nonuniform distortion due to mutual constraints between the grains of an aggregate. Authors claim that a plastic potential exists which is identical with the yield function. Upper and lower bounds are obtained for an approximate calculation of this function for any applied system of combined stresses.

Maximum work principle and minimum shear principle for single crystals and for polycrystalline aggregates are proved. [Latter principle was assumed by G. I. Taylor in 1938 ("S. Timoshenko Anniversary Volume," p. 218, Macmillan).] Authors give rough qualitative discussion to conclude that yield surface size is mainly a function of total plastic work. Proofs of extremum principles employ surface and volume integrals over a "unit cube" of material, where unit cube is smallest cubical volume having homogeneity property of polycrystalline aggregate. Authors assume no cavities are formed and no sliding occurs along grain boundaries. Microscopic stress may be discontinuous across grain boundaries so long as the stress resultants on both sides are equal. No attempt is made to apply method for calculation of bounds on yield surface, and no estimate is given of the magnitude of the difference between bounds.

Robert C. Meacham, USA

105. Nye, J. F., The flow of glaciers and ice-sheets as a problem in plasticity, *Proc. roy. Soc. Lond. Ser. A*, **207**, 1091, 554–572, July 1951.

Ice is regarded as an isotropic solid in which plane plastic deformation takes place under a constant maximum shear stress (of order 10^6 dynes/cm^2). Approximate solutions are obtained for steady-state flow (active or passive) of a long shallow glacier down a rough slope under the influences of gravity, snowfall, and ablation. The velocity is greatest at the surface and decreases elliptically with depth. Similar solutions for the flow of very thick ice are applied to calculations of the profile and manner of flow of the Greenland ice sheet.

Formation of crevasses is attributed to tension stresses near the surface, and faults to the propagation of disturbances along planes of maximum shear stress. Several well-known phenomena are qualitatively explained on this basis. R. Hill, England

106. Tobolsky, A. V., Dunell, B. A., and Andrews, R. D., Stress relaxation and dynamic properties of polymers, *Text. Res. J.* **21**, 6, 404–411, June 1951.

Using the Maxwell relaxation theory, authors try to correlate the dynamic properties of the idealized linear polymer with its stress relaxation phenomenon. For a simple rectangular distribution of relaxation time, the following relation is obtained: $\omega\eta_{dyn} = \pi E^0/2\ln 10 = 0.682\ E^0$, where η_{dyn} is dynamic viscosity, ω radian frequency, and E^0 negative slope of relaxation curve plotted as reduced stress vs. logarithm of time. Comparisons of observed values of $\omega\eta_{dyn}$ and values given by above equation show a fair agreement in magnitude for some rubbers and fibrous materials.

Reviewer believes that the Maxwell body behaves somewhat differently from what authors postulate.

Firstly, the Maxwell relaxation formula is only linear in the plot of the logarithm of reduced stress vs. time. This may be seen directly from Eq. (2) in text. Therefore, E^0 is not a constant for a Maxwell body in the plot used by authors. Though it may be possible to have such a combination of Maxwell elements to make E^0 of the whole system for a certain time interval, some restrictions have to be imposed on the body considered then.

Secondly, a change in value of the relaxation time will not shift the relaxation curve horizontally as stated by authors. It only spreads the relaxation curve over more cycles of logarithm time. By Eq. (2), one may see that the stresses at time equal to zero must be the same, no matter how the value of relaxation time changes while E and S_a remain constant.

Lastly, the difficulty of determining the stress relaxation accurately at the beginning of a test should be pointed out, for stress relaxation takes place as soon as stress is applied, if the material follows the Maxwell relaxation theory. Therefore, the stress at the end of the loading process is not exactly the theoretical initial stress. It is only the stress after an amount of relaxation, especially important due to the characteristic of function $e^{-t/\tau}$. Taking this into consideration, relaxation time τ as determined is lower than it should be. This may explain the deviations in $\omega\eta_{dyn}$ given in Tables I and II.

Ling-Wen Hu, USA

107. **Oding, I. A., and Volosatova, E. N., Relaxation of austenite steel at room temperature** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **71,** 4, 659–662, Apr. 1950.

108. **Oding, I. A., and Tseitlin, V. Z., Criteria of steel relaxation and their application** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **71,** 5, 883–886, Apr. 1950.

109. **Needs, S. J., The Kingsbury tapered-plug viscometer for determining viscosity variation with temperature and rate of shear,** Symp. Meth. Meas. Viscosity high Rates Shear, *Amer. Soc. Test. Mat. Spec. tech. Publ.* 111, 24–44, 1951.

Four mineral oils, two containing polymer additives, were investigated in a Kingsbury tapered-plug viscometer [*Mech. Engng.* 55, 685–688, 1933]. This instrument shears oil between a rotating tapered plug and a close-fitting ring. Thickness of oil film is varied by micrometer screw elevating plug.

The oils were studied in range of rates of shear from 3000 to 1,800,000 sec^{-1} and in temperatures from 70 F to 298 F. True viscosities of oils for various temperatures were determined by extrapolation to zero rate of shear. At high shear rates heating effects were observed but were comparable for all oils. No deviation from Newtonian flow attributable to high rates of shear were observed for straight mineral oils; however, polymer blends showed viscosity decreases of 15% and 38% for low- and high-molecular weight polymers, respectively. Maximum decrease is reached at 50,000 sec^{-1} at lower temperatures and 1,000,000 sec^{-1} at higher temperatures. No permanent decrease in viscosity was observed.

Nature of polymers or composition of blends are not given.

S. P. Jones, USA

110. **Torre, C., Mechanics of limiting stress** (in German), *Öst. Ing.-Arch.* **4,** 1, 93–108, 1950.

The limiting stress for plastic flow of ductile materials and failure of brittle materials is represented by a diagram consisting of a series of stress-strain curves. The stress system considered is hydrostatic pressure followed by other types of loading. The separation of the total strain into elastic and plastic components is considered in detail, but is based on a deformation type of law, and so applies only to very limited systems of loading.

The limiting stress criteria are associated with flow directions, which are discussed in terms of the Mohr type diagram. No significant advance appears to be contained in this paper.

E. H. Lee, USA

111. **Vitovec, F., and Slibar, A., Determination of the form of the neck appearing in a tensile test** (in German), *Öst. Ing.-Arch.* **4,** 1, 75–88, 1950.

Authors attempt to find a mathematical expression, based on physical considerations, for the neck appearing on a cylindrical tension specimen. Up to now, empirical formulas have been used whose validity was confined to parts of the specimen. Starting with the assumption that a permanent deformation can be represented by the sum of elementary displacements, the statistical distribution of gliding over the length of the specimen is computed on the basis of the theory of probability.

From authors' summary by B. Gross, Brazil

112. **Rotherham, L., Smith, A. D. N., and Greenough, G. B., Internal friction and grain boundary viscosity of tin,** *J. Inst. Metals* **79,** part 6, 439–454, 1951.

Internal friction and Young's modulus were determined for high purity tin at very low bending stress (where stress level is not a variable) by a vibration-decay method at audiofrequencies. Both polycrystalline and few-crystal specimens were examined over the temperature range from 15 to 150 C. The purpose of this work was to extend physics-of-metals knowledge on grain-boundary behavior rather than provide engineering property data.

Internal friction was associated with viscous grain-boundary slip as indicated by prior work. Activation energy associated with the slip process was consistent with steady-state creep data of a single crystal but inconsistent with activation energy for self-diffusion as predicted by prior work. B. J. Lazan, USA

113. **Colonnetti, G., Practical value of a theory of elastoplastic equilibrium** (in French), *C. R. Acad. Sci. Paris* **232,** 7, 584–585, Feb. 1951.

Author defends his theory of elastoplastic equilibrium against criticism that it is an idealization, claiming that, like classical elasticity, it represents the important limit of the least possible complexity. F. R. N. Nabarro, England

114. **Green, A. P., A theoretical investigation of the compression of a ductile material between smooth flat dies,** *Phil. Mag.* (7), **42,** 331, 900–918, Aug. 1951.

Author develops a two-dimensional theory, based on the assumption of an ideal plastic behavior, describing the stress and velocity distributions in a block of ductile material symmetrically indented on opposite sides by two smooth flat dies. Paper indicates that the velocity field transforms into its corresponding slip-line field. Examples for width-to-height ratios between one and two are computed, and it is shown that simple analytical relations hold between these ratios and the corresponding velocity discontinuities in the field. Using Hill's upper and lower bound curves (based on extremum principles) for comparison, it is shown that the calculated mean pressures on the dies compare favorably with the latter. Photographic experimental evidence is presented, illustrating the deformations due to various finite indentations of plasticine models and aluminum alloy strip.

Harry H. Hilton, USA

Failure, Mechanics of Solid State

(See also Revs. 110, 128, 129, 130)

115. **Yoffe, E. H., The moving Griffith crack,** *Phil. Mag.* (7), **42,** 330, 739–750, July 1951.

The distribution of stress produced by a Griffith crack of fixed length moving with constant velocity through an infinite elastic solid is calculated. The method of solving the elastic equations is similar to that employed by Eshelby [AMR **3,** Rev. 1450] in his discussion of a moving dislocation. Stresses are shown to depend on the velocity and to reduce to the Inglis' solution [*Trans. Instn. nav. Archit.*, p. 219, 1913] when the velocity of the crack is zero. If the material is such that a crack spreads in a direction perpendicular to the maximum tensile stress, it is deduced that there is a critical velocity, 0.6 times the velocity of shear waves, at which the crack tends to become curved. At a lower speed the crack extends in a straight line, but as the speed increases the crack may form branches, and at higher velocities each branch tends to curve. Ian N. Sneddon, England

116. **Isibasi, T., Strength and deformation of low carbon steel bars with a round-crack under statical and repeated loads,** *Memo. Fac. Engng. Kyushu Univ.* **12,** 3/4, 281–308, 1951.

Author is concerned with effects of cracks in structures, particularly welded ones, and effects of low-temperature annealing. Investigation consists of tensile, bending, and fatigue tests on notched round bar specimens (17-mm diam) having circumferen-

tial cracks. Initial cracks were formed at base of notch by fatigue loading in rotary bending. Photographs presented show discontinuous mode of penetration of cracks in tensile tests. Annealing at 600 C was found to reduce fatigue limit considerably; author suggests this is due to softening of strain-hardened material at root of crack. He also suggests that such annealing will reduce fatigue strength of welded members if cracks are initially present. For specimens with 0.5-mm crack depth and annealed at 600 C, fatigue notch factor K_f of about 2 is found; this drops to about 1.5 for annealing at 220 C, nominal stresses being figured on minimum section. Data for specimens having deeper cracks (about 1 to 2 mm) are quite scattered but appear to indicate higher fatigue limits (i.e., lower K_f values) than for shallower cracks. Reviewer believes this is due to method of calculating nominal stress and that, if such stress were calculated assuming that cracked area may carry compressive load [Peterson, *Trans. Amer. Soc. mech. Engrs.*, p. 157, Oct-Dec., 1933], higher K_f would probably be found for the deeper cracks.

A. W. Wahl, USA

117. Glikman, L. A., and Davidenkov, N. N., Effect of cold-hardening on fatigue limit of steel (in Russian), *Zh. tekh. Fiz.* **21,** 9, 573–578, May 1951.

Repeated bending tests are performed on stainless steel (0.11% C, 14% Cr) plastically deformed by uniaxial compression. Preceding compressive deformations of 20 and 40% raise fatigue limit by 8% and 13.5%, respectively. Oding ["Allowed stresses in engineering," Masch GIZ, 1944], measuring on plain carbon steels previously compressed by 20%, found same qualitative result. Quantitative difference is explained by little tendency to strain-aging and by small strain-hardening modulus of chrome steel. Results are not in accordance with assumption that orientation of inhomogeneities in microstructure influences fatigue limit. Heinrich Mussmann, Germany

118. Stickley, G. W., and Howell, F. M., Effects of anodic coatings on the fatigue strength of aluminum alloys, *Proc. Amer. Soc. Test. Mat.* **50,** 735–742, 1950.

Authors discuss effects of various commercial anodizing treatments on fatigue strength of unnotched specimens of 17S-T3, 17S-T4, 25S-T6, and 75S-T6 aluminum alloys. Data for notched specimens 75S-T6 also given. Authors conclude thin coatings (0.0001 to 0.0002 in.) on smooth surfaces have little or no effect. Thick coatings (0.0005 to 0.0010 in.) have slightly detrimental effect at higher stresses but none was noted below 17,000 psi. Fatigue strength in presence of severe stress raisers was not adversely affected by anodic coatings. Conclusions are supported by findings of independent investigators. Reviewer believes future studies might benefit additionally through the use of testing methods which allow statistical analysis of data.

G. M. Sinclair, USA

Material Test Techniques

(See also Revs. 31, 59, 135, 145)

119. Templin, R. L., and Aber, W. C., A method for making tension tests of metals using a miniature specimen, *Proc. Amer. Soc. Test. Mat.* **50,** 1188–1194, 1950.

Paper describes techniques and instruments that have been used, and precautions to be observed, when using miniature tensile test specimens. Experiments were conducted on several series of specimens varying in diameter from the standard 1/2-in. specimen through seven smaller sizes down to 0.050-in. diameter. Authors show the feasibility of obtaining data from miniature specimens that are comparable with the results obtained from standard 1/2-in. specimens. The results indicate that miniature specimens can be used satisfactorily for the determination of tensile strength, yield strength, elongation in $4D$, and perhaps for reduction of area provided the material has relatively fine grain structure. The errors need not be greater than those for standard 1/2-in. specimens provided proper attention is given the details of testing technique. The methods offer a wide field of usefulness in tests of sheet stock or of members for which the metal available for test is limited in size. T. J. Dolan, USA

120. Dolan, T. J., Electrically excited resonant-type fatigue testing equipment, *Amer. Soc. Test. Mat. Bull.* no. 75, 60–67, July 1951.

A new fatigue testing machine is described that is operated and controlled by simple electrical circuits. The loads are applied by inertia forces from two heavy masses between which is suspended the test specimen. The system operates as a "tuning fork" which subjects the test specimen to vibratory bending stresses; it is automatically excited electronically in resonance with the natural frequency of the assembly (usually 40 to 100 cps). The difficulty of controlling the amplitude of the resonant vibration within narrow limits has been solved satisfactorily by employing a new and relatively simple circuit actuated from a micrometer screw that is used to pre-set the amplitude desired. Advantages and adaptability of the equipment for other uses are discussed briefly. Preliminary results are presented from flexural fatigue tests of round and of square specimens of 24S-T4 aluminum alloy to show the effect of shape of cross section on the fatigue strength.

From author's summary by H. Palm, Holland

121. van Maanen, J. J. L., New methods for the study and testing of metals, and their application to welded structures (in French), *Rev. Soud.* **7,** 1, 1–15, 1951.

Article outlines theoretical concepts underlying new method of impact testing introduced and patented by H. Schnadt and used extensively in European industry for acceptance, development, and control of materials, mainly steels.

State of stress at any point in solid is characterized by largest principal tensile stress, and dimensionless quantity called "plastifying power," which is function of quadratic invariant of stress tensor expressed in terms of two principal stress ratios. All conceivable states of stress can be plotted in two-dimensional diagram with points of equal "plastifying power" lying on ellipses. State of strain is similarly characterized by strain ratios and dimensionless "straining power." Three-dimensional stress-strain relations are given by one equation between "plastonic strain" and "plastonic stress," which are functions of plastifying power and straining power, respectively.

Behavior of metal under stress at given temperature is represented schematically in a diagram plotting maximum principal stress against plastifying power. Three curves separate the area into regions of elastic deformation, plastic deformation, ductile fracture, brittle fracture after plastic deformation, and brittle fracture without plastic deformation. As plastifying power decreases, normal stress to produce plastic deformation increases. At critical value of plastifying power for given temperature and straining speed, ductile failure changes into brittle fracture.

Structural failure, against which conventional testing methods provide no safeguard, takes place at lower temperature under shock loading, starting from unsuspected crack. Cracks are more likely to be present in welded structures than riveted structures, hence plastifying power of former is generally lower than that of latter. Absolute value of plastifying power in structure is not ascertainable, hence arbitrary scale in new "Venant units"

is introduced, related to series of nine impact specimens of Charpy type with compression zone removed and replaced by tungsten carbide pin. Test pieces are provided with V-notches of increasing severity, i.e., with notch root radii increasing from zero to infinity. Zero root radius notch is made by novel technique of pressing with tungsten carbide knife. Main advantage of new test piece is that no energy is absorbed by upsetting in compression. Most severe, "coheracic," test piece with zero root radius represents most severe stressing conditions encountered in welded structures in presence of unsuspected crack. Hence, new technique is particularly important for testing materials for welded structures. Coheracic material, i.e., material with satisfactory energy absorption of coheracic test piece, will resist crack propagation.

Test pieces serve to establish "thermal homofractance" curves for given material which can be related experimentally to behavior of constructional details at given service temperature. A number of other concepts relating to brittle fracture such as decohesion level, contraruptive stress, endobrittleness, paratential, etc., are explained.

(Those not reading French will find a similar article in English by reviewer in *Trans. Inst. Welding, London*, April 1950.)

R. Week, England

122. **Pavia, R. V., An investigation into engine wear caused by dust,** *Aero. Res. consult. Comm., Australia Rep.* ACA-50, 19 pp., July 1950.

A number of wear tests have been made on an R.1830 Twin Wasp single-cylinder engine with dust introduced into the intake air, to study the effects on engine wear of dust quantity, dust concentration, and dust size. The results show that, generally, the wear is proportional to the weight of dust fed, but the amount of wear produced by a given weight of dust decreases as the dust concentration increases. Maximum wear was obtained with a dust size of about 15 microns, while the wear with 100-micron dust was only half as much.

A simple method, which agrees well with the experimental results, has been suggested for estimating the wear caused by a mixture of dusts with known individual wear characteristics.

From author's summary

123. **Wilkes, G. B., Jr., Stress-corrosion tests on turbosupercharger materials in the products of combustion of leaded gasoline,** Sympos. Corr. Materials elevat. Temperat., *Amer. Soc. Test. Mat. Spec. tech. Publ.* 108, 11–23, 1951.

Stress-corrosion tests were made on 18 alloys. The corroding agents were the products of combustion of leaded aircraft gasoline. Tests were made under both constant temperature and cyclic temperature conditions. Under the conditions of these tests, the combustion products are somewhat corrosive if the temperature is cycled, but not at constant temperature. The acceleration of strain due to temperature cycling alone has a greater detrimental effect on strength.

From author's summary

124. **Chefdeville, J., and Dawance, G., Vibratory method of measuring the modulus of elasticity of concrete in site and on test bars** (in French), *Ann. Inst. tech. Bât. Trav. publics* (*N.S.*) no. 140, 27 pp., July-Aug. 1950.

The first half of this report, by G. Dawance, describes three methods, developed at the Laboratoires du Bâtiment et des Travaux Publics, for measuring the dynamic modulus of concrete. In one method, a slender rod is excited into longitudinal resonance by a variable frequency electromagnetic vibrator. In the second method, the modulus is determined from the velocity of propagation of sound waves in the specimen. Two quartz crystals, one a sender and one a receiver, are placed at two ends of the specimen and the time needed for sound transmission is indicated on an oscilloscope with a horizontal time sweep graduated in units of 5 microseconds. A third method, suitable for actual concrete structures, uses a cam-driven mechanical hammer sending shock waves picked by a magnetostriction transducer, the time interval being measured as in radar. The accuracy of these methods is given as better than 3%. Linear propagation formulas are presented, as well as corrections for two- and three-dimensional effects and for effect of steel reinforcement.

In the second half of the report, J. Chefdeville presents test data obtained with this equipment. Charts are given, showing the increase of modulus of concrete as it hardens. Setting of concrete in water is compared to setting in air, the former producing a concrete of higher modulus. Other data show that the modulus of concrete might be predicted from the moduli of its constituents. However, a most important application of this equipment is the nondestructive testing of actual structures to indicate possible internal irregularities, fractures, or other defects not visible on the surface.

Alexander Yorgiadis, USA

125. **Masi, O., The x-ray test of welds: an attempt of quantitative evaluation of defects** (in Italian), *Metallurgia ital.* **63,** 7, 261–269, July 1951.

Paper begins with a quantitative interpretation of the faults in welding. Method consists in expressing photographic density of an x-ray photograph vs. actual thickness. Thus, an idea can be obtained of the thickness which the radiographed piece has in the direction of each ray. Author has obtained the same results by means of punctual determinations with photometer and by measuring the dimensions of the faults, or by microphotometric registering, along one section. He indicates the limits of the method, due to: (1) Unequal distribution of x-ray intensity on a plain screen; (2) necessity that the extended faults lie in the direction of the rays, or are perpendicular to them; (3) inequality of the opacity of the x rays in different inclusions that produce the same mechanic fault. There are other facts to which author does not give their real importance: (a) The diffusive radiation increases together with the faults, clouding the obtained results; (b) it is necessary to repeat the x-ray standard photograph on the plate; (c) the total resistance of the piece is not reduced in proportion with the section; it depends, on the contrary, essentially on stress concentrations which are not detected by this method. However, this method offers good possibilities, and the results obtained by author when breaking the radiographed pieces agree with the calculated resistance.

Leonardo Villena, Spain

126. **Van Horn, K. R., Discontinuities in cast and wrought products that can be revealed by nondestructive tests,** Sympos. Role nondestruct. testing in economics of production, *Amer. Soc. Test. Mat. Spec. tech. Publ.* 112, 83–101, 1951.

The ASTM Tentative Industrial Radiographic Terminology for the Radiographic Inspection of Castings and Weldments (E 52-49T) is illustrated by prints representing typical discontinuities for each subdivision. The sensitivity limitations and important applications are described briefly for four extensively used nondestructive tests—radiographic, fluorescent penetrant, magnetic particle, and ultrasonic methods. An attempt is made to define the discontinuities in the ASTM Terminology that are likely to be detected in nonferrous and ferrous castings and welds by these four tests. There is also some discussion of the types of discontinuities that may be revealed in wrought products by these methods.

From author's summary

127. Meredith, R., On the technique of measuring orientation in cotton by x-rays, *J. text. Inst. Trans.* **42,** 7/8, T275-T290, July/Aug. 1951.

Author discusses three ways of measuring orientation from photographic records. First method, due to Berkley and Woodyard [*Indust. Engng. Chem.* **10,** p. 451, 1938], is to find angular displacement from point of maximum blackening on (002) diffraction arc to point where absorption is 40% of maximum. Second method, due to author, is to use calibration strip so that microphotometer readings can be converted directly to x-ray intensities. Opacity of film and characteristics of microphotometer can then be eliminated. Third method, due to Hermans [*Rec. Trav. Chim.* **65,** p. 427, 1946], is to measure distribution curve of intensity around maximum. Author finds good correlation between first two methods when corrections are made, but third method does not correlate well with other two due to differences in shape of distribution curve with different cottons. Experimental technique of photographing and measuring x-ray patterns is described fully. H. Kolsky, England

Mechanical Properties of Specific Materials

(See also Revs. 106, 107, 108, 112, 118, 124, 127, 258)

128. Wood, W. A., and Head, A. K., Some new observations on the mechanism of fatigue in metals, *J. Inst. Metals* **79,** part 2, 89–102, 1951.

Using x-ray diffraction methods on copper and aluminum specimens, authors have compared the effect of static and cyclic stressing on the crystalline structure of a metal. Other research has emphasized the similarity in changes in microstructure; this work emphasizes the dissimilarity resulting from the two types of stressing.

Observations made are: (1) Unidirectional static stressing produces an extensive and progressive derangement of the internal structure of the grains; (2) reversing a plastic strain reduces the disorientation caused by the strain; (3) the disorientation produced by the same stress cycle is marked when it is applied at a low speed and very slight at a high speed; (4) a critical speed exists, independent of the applied stress, above which derangement of the internal structure of the grains is largely suppressed. The critical speed for suppression of disorientation was established for copper under alternating tension/compression to be between 300 and 400 cpm.

Authors theorize that suppression of plastic flow by action of cyclic stressing above the critical rate transforms normally ductile metal into a brittle medium, thus accounting for some of the basic factors associated with failure of metals in fatigue.

H. R. Neifert, USA

129. Tarasov, L. P., and Grover, H. J., Effects of grinding and other finishing processes on the fatigue strength of hardened steel, *Proc. Amer. Soc. Test. Mat.* **50,** 668–687, 1950.

Paper presents results of an investigation of the effect of grinding and other finishing processes on the fatigue strength of a ball-bearing type steel, very similar to type 52100, at Rockwell hardness levels of C 45 and C 59. Grinding scratch direction was always parallel to the specimen length. Two types of fatigue tests are used: reversed-bending tests with flat bars of 0.120-in. thickness, and rotating-bending tests with round bars which had a final diameter of 0.230 in. In tests with flat bars the endurance limit of gently ground bars could not be increased by electrolytic or hand-polishing. Endurance limits for severely ground bars were found 25% below the values for gently ground bars. Even these low values could not be increased significantly by polishing. Shotpeening and abrasive tumbling, however, greatly increased endurance limits of both gently and severely ground bars and to the same level, about 30% higher than the values for gently ground bars. Authors conclude that increase of surface smoothness beyond a reasonable value has no significant effect on endurance limits, and they explain the experienced phenomena in terms of residual stresses, severely ground bars having residual tensile stresses and shotpeened bars having residual compression stresses. With round bars, endurance limits were found about twice as high as with gently ground flat bars. Moreover, no significant effects were found of the various surfacing processes. Authors suggest these discrepancies are related to differences in specimen geometry. J. H. van der Veen, Holland

130. Grover, H. J., Fatigue notch-sensitivities of some aircraft materials, *Proc. Amer. Soc. Test. Mat.* **50,** 717–729, 1950.

A detailed examination was made of published data on the fatigue properties of three SAE steels (4130, 4140, and 4340), two aluminum alloys (24S-T and 75S-T), and one 18-8 stainless steel. This disclosed that the notch sensitivity index $q = (K_f - 1)/(K_T - 1)$, where K_f is the fatigue-strength reduction factor and K_T the theoretical stress concentration factor, varied nearly as much among results of different tests on one material as among different materials. Author concludes that q may be inadequate as a general fatigue notch-sensitivity index. Several suggestions are made for the use of theoretical stress-concentration factors in the place of strength-reduction factors. (Reviewers note. That q varies widely with notch radius for a given material has already been shown by R. E. Peterson [*Amer. Soc. Test. Mat. Bull.* no. 133, Mar. 1945].)

Charles W. MacGregor, USA

131. Holmberg, M. E., Experience with austenitic steels in high-temperature service in petroleum industry, *Trans. Amer. Soc. mech. Engrs.* **73,** 6, 733–739, Aug. 1951.

Experience in the petroleum industry shows there are other factors besides tensile, creep, and stress rupture to consider in the use of austenitic steels in high-temperature service. There is no advantage in using stabilized grades in many applications. A spheroidizing heat treatment is generally effective where stabilized steel is required. The coefficient of expansion and the thermal conductivity have been important factors in thermal-shock and thermal-fatigue failures in austenitic steels.

From author's summary

132. Holt, M., and Eaton, I. D., Effects of design details on the fatigue strength of 355-T6 sand-cast aluminum alloy, *Nat. adv. Comm. Aero. tech. Note* 2394, 45 pp., July 1951.

Static and fatigue tests were made on 355-T6 sand-cast plate-type aluminum-alloy specimens incorporating holes, bosses, and ribs.

In the static tests, the tensile strength of the plain plate-type specimen agreed within 3% with the strength of separately cast test bars. In terms of the average stress on the minimum net section of one specimen of each type, all the design details studied reduced the static strengths of the plate-type specimens. The reductions ranged from 4650 to 9000 psi or 13 to 26%.

Of the design details studied, the unreinforced hole was the most effective stress-raiser for fatigue lives from 10,000 to 25,000,000 cycles. The unreinforced hole in the sand-cast specimen was not so severe in reducing the fatigue strength as a similar hole in wrought 17S-T4, 27S-T6, 53S-T6, or 14S-T6 plate.

The fractures of both the static and fatigue specimens with a boss or rib were generally in cross sections close to the edge of the boss of rib. From authors' summary

133. **L'Hermite, R., Recent research on vibration of fresh concrete** (in French), *Lab. Bât. Trav. publics*, 16 pp., 1950.

Author studies workability of fresh concrete and its rheologic properties. By means of a rigidometer he shows that fresh concrete has internal friction as tensions are not canceled out through relaxation. It is possible to attribute to it a coefficient of viscosity with a corresponding angle α. Rigidity curves can be obtained as a function of the pressure of sand, cement, and concrete. The quantity of water has little effect upon the coefficient of friction, which depends on the grading of aggregates. It acts upon the viscosity which may be measured by means of Eriksson's fluidometer.

The effect of vibration of concrete is to cancel out internal friction up to a certain value of external pressure called "expansion." A mathematical interpretation shows that said expansion is proportional to the square root of the vibratory energy. A standardization method with respect to vibrators may be worked out. It is possible to estimate the absorption coefficient of concrete which depends on grading of aggregates and frequency of vibrations.

Author studies the vibrating plate and gives results of measurement of the amplitude, established as a function of the load. Resonance phenomena make it possible to calculate the velocity of propagation of energy which attains 35 to 45 meters/second. By means of a piezometric device, it may be found that, during vibration, the action of concrete upon the walls of the mold is comparable to the buoyancy of a liquid, the density of the liquid being that of concrete.

From author's summary by Andrew Brodsky, USA

134. **Fried, N., Winans, R. R., and Sieffert, L. E., Effects of elevated temperatures on strength of thermosetting plastic laminates,** *Proc. Amer. Soc. Test. Mat.* **50,** 1383–1398, 1950.

Authors carried on tests on the effects of high temperature upon the mechanical, particularly the strength, properties of laminated plastics. The materials evaluated were fabric-base phenolic laminate, paper-base phenolic laminate, and glass-melamine laminate. Flexural and compressive tests were made of material unheated and material heated to various temperatures for short times (1, 2, or 4 hr) and for long times (periods ranging from 4 hr up to 768 hr) at temperatures as high as 250 C. As a consequence of these tests, authors suggest maximum operating temperatures (M.O.T.): For glass-melamine, 150–200 C; for paper-base phenolic, 100–150 C; for fabric-base phenolic 100–150 C.

Paper is timely in view of the increasing requirements for plastics and laminates to be employed at elevated temperatures.

Albert G. H. Dietz, USA

135. **Rorden, H. C., and Grieco, A., Measurement of dynamic internal dissipation and elasticity of soft plastics,** *J. appl. Phys.* **22,** 6, 842–845, June 1951.

Two instruments are described for measuring the dynamic mechanical properties of soft plastics in shear. A horizontal oscillating pendulum operates in the range of a cycle per second by shearing the test specimen between a fixed support and the oscillating pendulum. The modulus and damping are calculated from the change in frequency and decrement caused by the plastic sample. The second apparatus uses a vibrating tuning fork in the frequency range from 100 to 10,000 cps, as described by Hopkins [AMR **4,** Rev. 3570]. The size of samples used with these instruments is very small.

Data on shear modulus (rigidity), internal viscosity, and Q value (ratio of the reactance of the specimen to its resistance) are given for several rubbers and soft plastics over the frequency range of 2 to 6000 cps. In general, an increase in frequency causes an increase in rigidity, a decrease in viscosity, and very little change in Q value. Comments are made on the usefulness of such data from the engineering standpoint.

Lawrence Nielsen, USA

136. **Axilrod, B. M., and Sherman, M. A., Effect of stress-solvent crazing on tensile strength of polymethyl methacrylate,** *Nat. adv. Comm. Aero. tech. Note* 2444, 19 pp., Aug. 1951.

When tensile specimens of heat-resistant and ordinary-grade polymethyl-methacrylate sheet are stress-solvent crazed with benzene in a controlled manner to produce crazing cracks roughly 1 mm in length and 0.1 to 0.2 mm in depth and with a density of about 2 cracks per sq mm, the strength is reduced approximately 30%.

The coefficient of variation of the tensile strength of the crazed specimens is approximately 15% compared with about 5% for the controls. In addition, although the crazing was done in a controlled manner, there is a daily variation in the treatment that contributes an additional variability of roughly 15% to the coefficient of variation for the crazed specimens.

The tensile strength of a specimen of polymethyl methacrylate, crazed to the extent indicated above, cannot be predicted from the appearance of the crazing.

The use of acrylic aircraft enclosures that contain crazing as severe or more so than that described above is not recommended if, in service, tensile stresses normal to the crazing cracks exist.

From authors' summary

137. **Hermans, P. H., and Kast, W., On the stretching phenomenon in artificial cellulose fibers** (in German), *Kolloid Z.* **121,** 1/2, 21–32, Feb. 1951.

For the complete description without hypothesis of the orientation state of lamellar particles, two independent data concerning the axial and plane orientation are necessary. The methods of measuring the orientation by means of the half-width parameter according to Kast, or by means of the square deviations according to Hermans, were discussed extensively.

The variation of this pair of parameters in function of the stretching is calculated for the two methods according to the orientation theories of Krotky for the rodlet- and lamelliform particles as a result of the affined deformations of their vicinity.

The existence of different ratios of axial and plane orientation can be deduced from the comparison between the observed and the calculated parameters, not only for different methods of stretching but also during one single stretching. The rodlet case of Krotky was, in consequence, transformed into a lamelliform case, at which case, through the nonexistence of a network, there are no transverse forces; while in the lamellar case of Krotky there is such a strong net forming that longitudinal and transversal forces of the same intensity appear. The test samples obtained by a series of technical stretching processes give these two cases as boundary cases, and the observed intermediate values of these two forces can be explained by the presence of networks of different strengths (for different stretching processes) or by the different ratios of the orientational speed and the relaxation frequency of the netforming (during this single process).

From authors' summary by D. DeMeulemeester, Belgium

138. **Martorell, J. T., Contribution to the study of hardness and of the resistance capacity of metals** (in Spanish), *Técn. Metalúrg.* **7,** 59, 109–123, Apr. 1951.

Author presents and discusses fundamental and recent methods used for determining hardness and resistance capacity of metals, especially those based upon Meyer's law which governs the relation between force and diameter of indentation for the

Brinell hardness test. Using the mechanical theory of the contact of elastic bodies developed by H. Hertz, a new modulus of plasticity is introduced which corresponds to Young's modulus. The Meyer's constants are then determined from the variations of penetration within the plastic limits. It is also shown how it is possible to determine the limits of plasticity and the hardness ("elastic hardness") of a material on the basis of Meyer's constants found experimentally. Paper is divided into the following chapters: (1) Penetration tests; (2) Meyer's law; (3) Law of similitude; (4) Applications of Meyer's law; (5) Relationship between Brinell's hardness and resistance; (6) Theory of plastic hardness; (7) Limitations of elastic penetration; (8) Experimental methods; (9) Results; (10) Conclusions.

J. J. Polivka, USA

139. Horio, M., and Onogi, S., Dynamic measurements of physical properties of pulp and paper by audiofrequency sound, *J. appl. Phys.* **22, 7, 971–977, July 1951.**

The dynamic Young's moduli of various types of paper were measured by the vibrating reed method. The Young's modulus of paper increases statistically at a rate approximately proportional to the square of its density. The modulus and density of paper increase with the degree of beating. The sulfite and sulfate fibers behave differently during beating. The angular dependence of Young's modulus, tensile strength, and elongation at break was analyzed mathematically, and the results were verified by experiments. According to this theory, the mean value of Young's modulus and tensile strength of machine-made paper should be expressed by the geometrical mean of the values of the machine and cross directions, whereas the mean value of elongation can be given by the arithmetical mean. The removal of parenchyma cells is very effective in reducing the Young's modulus of dissolving pulp. The viscoelastic properties of paper were observed within the frequency range from 20 to 180 cps. The dynamic modulus and mechanical loss factor of the sheets employed were found to be smaller than one tenth of those of cellulose films. The interfiber deformation influences the dynamic properties of paper. From authors' summary

140. Seshagiri Rao, T., Elastic constants of barytes and celestite, *Proc. Indian Acad. Sci. Sec. A*, **33, 5, 251–256, May 1951.**

The elastic constants of barium sulphate and strontium sulphate are determined, using the wedge method. The values for barytes obtained by Bergmann and Voigt are verified. The elastic constants for strontium sulphate are determined for the first time and they are: $C_{11} = 10.44$; $C_{22} = 10.61$; $C_{33} = 12.86$; $C_{44} = 1.35$; $C_{55} = 2.79$; $C_{66} = 2.66$; $C_{23} = 6.19$; $C_{13} = 6.05$; and $C_{12} = 7.73$. From author's summary

141. Bollenrath, F., Bungardt, W., and Gröber, H., Effect of heat treatment on the strength of propellers of aluminum-zinc-magnesium alloys (in German), *Z. Metallk.* **42, 12, 463–469, Dec. 1950.**

The effect of various heat treatments (12 to 168 hr at 80 to 125 C), after aging at room temperature, on the static and fatigue strength of aluminum alloys for airplane propellers was determined on specimens from three forged bars and from two propeller blanks, all of alloys with low copper content. Fatigue tests were made on the usual rotating beam specimens with and without notches and, in addition, pulsating compression tests were made on an ingenious disk-shaped specimen to simulate the transmission of force through a screw thread at the base of the propeller blade. The tests showed that the heat treatment resulted in a substantial increase in static strength, as expected, and that this was accompanied by no significant change in the fatigue strength of the notched specimens.

Walter Ramberg, USA

142. Cagle, F. W., Jr., and Eyring, H., An application of the absolute reaction rate theory to some problems in annealing, *J. appl. Phys.* **22, 6, 771–775, June 1951.**

Authors present an excellent semi-empirical development of a possible molecular model to explain the annealing of metals and glass. Accepting the single postulate that the internal stress is proportional to the number of stress sites, the derivation follows in a straightforward manner, yielding the two experimentally correct annealing laws: The first, valid for glass, is that the rate of removal of the stress is proportional to the square of the stress. The second, valid for metals, is that the rate of removal of stress is proportional to the stress. However, it is reviewer's opinion that the original postulate is extremely vague and requires considerable investigation and/or justification.

Derald A. Stuart, USA

143. Freas, A. D., and Werren, F., Mechanical properties of cross-laminated and composite glass-fabric-base plastic laminates, *For. Prod. Lab. Rep.* **1821, 12 pp., 10 tables, 3 figs., Feb. 1951.**

The mechanical properties of glass-fabric laminates can be varied by changing the orientation of the laminations or by using different laminations. Hence, the problem arises of predicting the properties of an arbitrary laminate construction from the properties for a simple construction. This report describes limited experiments in which mechanical properties measured on a few crossed-ply and one composite laminate are compared with values predicted from data [see title source, *Reps.* 1803 and 1803A] obtained on corresponding parallel-ply laminates. Tensile, compressive, bending, and panel shear tests were made, mainly in the warp or fill direction. Several methods for predicting the properties are described and compared. For the methods considered most satisfactory, the predicted and observed values of modulus of elasticity and ultimate strength agree usually within 10 or 20%, which is considered reasonable. A minor point: the glass fabrics are not adequately described.

B. M. Axilrod, USA

144. Siegfried, W., Contribution to the determination of failure in creep at multiaxial stress after cold working (in French), *Rev. Métall.* **48, 6, 413–433, June 1951.**

Author is interested in creep problem occurring in turbine blades. One steel investigated was essentially 18-8, the other had 13% Cr and 13.0% Ni. Creep tests on first steel were made at 600 C "as received," after 10% reduction by drawing, and 10 and 20% cold-working (outer surface) by twisting. Second steel was tested at 650 F with similar conditioning plus hot working at 600 C. Specimens tested consisted of smooth and grooved cylindrical specimens and units with dovetailed joints. Test results were supplemented by metallographic and x-ray diffraction studies.

Two steels did not react similarly to prior working. This difference is attributed to variations in dislocation and recrystallization characteristics of steels. For first approximation, hydrostatic tension portion of combined stress controlled probability of rupture. Tests did not permit verifying whether, or to what extent, deviation action of stress effected rupture. Resistance to creep is increased by hot working; however, notch sensitivity also increases.

Investigation is significant because of its completeness and thoroughness. Frank J. Mehringer, USA

145. **Hadden, S. E., and Perryman, E. C. W., The effect of surface finish on the stress-corrosion properties of aluminum-7% magnesium alloy,** *Metallurgia, Manchr.* **42,** 254, 392–396, Dec. 1950.

146. **Rinehart, J. S., Work-hardening of mild steel by explosive attack,** *J. appl. Phys.* **22,** 8, 1086–1087, Aug. 1951.

Hardness measurements made on sectioned mild steel plates following detonation of explosives at the plate surface show a thin layer immediately below the surface in which work-hardening is concentrated. Hardness decreases sharply in this region with increasing distance from the surface, then remains constant for a certain distance, and then gradually approaches the original hardness of the plate. A theory is proposed to explain the characteristics of the hardness-distance curve, based on two mechanisms of flow (slip and twinning) and on conditions which favor each.

Carl A. Keyser, USA

147. **Moore, D. G., Bolz, L. H., Pitts, J. W., and Harrison, W. N., Study of chromium-frit-type coatings for high-temperature protection of molybdenum,** *Nat. adv. Comm. Aero. tech. Note* 2422, 39 pp., July 1951.

A number of chromium-frit-type coatings were studied. These were bonded to molybdenum specimens by firing in controlled atmospheres to temperatures in the range 2400 to 2700 F. The durability of the coatings was then studied, principally by means of oxidation tests under load in the range of 1500 to 1800 F and by flame tests in the range of 2000 to 3000 F. The results may be summarized as follows: (1) Frit (glass), when used in conjunction with the chromium in the coating, gave coatings with considerably better durability than similar coatings containing no frit. (2) Optimum protection at 2800 F was obtained when the frit was diffused into the previously fired frit-free chromium coating structure through application of a seal coat. (3) The resistance of the chromium-frit-type coatings to cracking by thermal strain, or by rapid creep, was not particularly good but, because of excellent adherence and the tendency of the glassy phase to reseal the fissures, cracking of the coating did not cause rapid failure but rather a weakening in the coating structure from which failure might begin. (4) At 2800 F and with no loading, the most durable coating protected the molybdenum for a maximum of 7½ hr. (5) The maximum temperature at which the chromium-frit-type coatings remained intact without flow in a high-velocity gas stream from an oxyacetylene torch was approximately 3000 F. (6) Maximum life achieved from coated specimens under load in an air atmosphere was 917 hr at 1500 F (0.6% creep), 2210 hr at 1650 F (1.7% creep), and 3275 hr at 1800 F (1.2% creep). At any one test temperature, higher creep rates resulted in shorter life.

From authors' summary

148. **Liu, S. I., Effects of precompression on the behavior of the aluminum alloy 24S-T4 during cyclic direct stressing,** *J. Metals* **3, 6,** 452–456, June 1951.

Paper presents an experimental study of the stress-strain and fracture characteristics of a material having various strain histories. Bulk of the work centers about specimens that have been prestrained in compression and subsequently given a cyclic direct stressing (tension-compression). The amount of prestrain and number of cycles are the important variables. True stress and natural strain are used in the plots.

Author concludes that cyclic straining creates strain hardening and deterioration, two superimposed effects which counteract one another. After a small precompression, former prevails during first few cycles, while after large precompression, latter predominates. He also points out that precompression and cyclic straining are individual influences in reducing the fracture stress. When combined, the effect is greater than the sum of the two individual effects.

Julius Miklowitz, USA

Mechanics of Forming and Cutting

(See also Rev. 114)

149. **Feng, I.-M., Applications of polystyrene particles in conjunction with shadow casting to the study of polished metallic surfaces,** *J. appl. Phys.* **22,** 6, 820–824, June 1951.

In this study of polished metallic surfaces with the electron microscope, negative collodion replicas are used. Determination of width and depth of scratches by means of polystyrene particles and shadow-casting is discussed. Experimental results are summarized: The effect of polishing pressure applied is that greater pressure gives wider and deeper scratches and also causes severer flow and distortion of metal near the scratch. In comparison with unidirectional polishing, multidirectional polishing gives better surface finish with fewer scratches which run in all directions and have a wide range of width and depth; mostly, they are shallower and narrower than would be the case with unidirectional polishing. The average widths and depths of scratches on surfaces polished with various conditions are also given. Harder abrasives give a higher depth/width ratio.

From author's abstract by H. A. Nancarrow, England

150. **Hahn, R. S., Design of Lanchester damper for elimination of metal-cutting chatter,** *Trans. Amer. Soc. mech. Engrs.* **73,** 3, 331–335, Apr. 1951.

Author gives a theoretical analysis of the rate of decay of self-excited or free vibrations of a long boring quill equipped with a Lanchester damper. The Lanchester damper consists of a metallic plug inserted into the hollow boring quill and is coupled with the quill through a thin film of air which behaves viscously. It was shown that critical damping cannot be obtained unless the ratio of the mass of the plug to that of the lumped mass of the quill is at least 8. It is further shown that the clearance for optimum decay of free vibrations is a function of radial clearance between plug and quill and is of the order of 0.001 in. for a quill 1⅛-in. diam × 6 in. long with a 54-gram plug weight. Experimental values of optimum decay of vibrations were in close agreement with those predicted by the theory.

It is unfortunate that the author did not state that a tool, as described in this paper, will actually reduce or eliminate chatter in metal cutting, for his experiments were carried out under nonmetal cutting conditions.

Erich G. Thomsen, USA

151. **Carro-Cao, G., About the "building-up" formation in metal chipping** (in Italian), *Metallurgia ital.* **63,** 7, 270–280, July 1951.

The structure of the built-up edge is investigated during the formation of segmented and continuous chips. The explanation is given with theories of plastic deformation and correlation of observations by other investigators. It is found that chip thickness has little influence upon formation of the built-up edge since it will occur even with thin chips of 0.002-in. thickness.

The problem of chip formation, when based upon the theory of plasticity, gives an understanding of the built-up edge and chip structure as well as of the subdivision of the built-up edge into two parts, one of which adheres to the chip and the other to the workpiece.

Sketches also illustrate the zones of compression and tension in the workpiece around the cutting edge. Chip formation is pictured as a periodic phenomenon just as the formation of the

built-up edge occurs periodically. The built-up edge exists when machining plastic as well as brittle materials, like cast iron. At cutting speeds above 230 fpm there is no built-up edge when cutting steel. It should be possible to determine, for a particular workpiece and tool material, the lowest cutting speed at which a better surface finish, due to absence of built-up edge, can be obtained. A. O. Schmidt, USA

Hydraulics; Cavitation; Transport

(See also Rev. 5)

152. **Middleton, H. K., and Matchett, S. W., Hydraulic research in the United States,** *Nat. Bur. Stands. misc. Publ.* 201, 190 pp., Aug. 1951.

Contains: List of contributing laboratories; table, nature and results of projects; subject articles in foreign publications; subject index.

153. **Viparelli, M., Preliminary report of research on high velocity flows** (in Italian), *Energia elett.* **28,** 1, 13–22, Jan. 1951.

Problem of high velocity in open channels is discussed with particular reference to air entrainment and frictional resistance. Data on this subject are compiled by various European and American investigators. A flume and apparatus and techniques for studying this problem at the University of Naples are described and some preliminary experimental data are presented.

Vito A. Vanoni, USA

154. **Tsubaki, T., Theory of hydraulic jump,** *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **6,** 2, 99–106, Jan. 1950.

Using an assumed mean velocity distribution over the depth of the jump and energy dissipation computed by use of Prandtl's equation, author is able to compute profile shapes for jumps. One parameter must be evaluated experimentally. Results check some experimental values fairly well, others rather poorly.

Dwight F. Gunder, USA

155. **Housel, W. S., Misconceptions in the use of surface tension in capillarity,** *Nat. Res. Counc. Highway Res. Board, Proc. 30th ann. Meeting,* 465–485, 1951.

Object of the discussion is to provide a mechanism for describing capillary rise to replace hypothetical surface tension. Both molecular attraction and repulsion are recognized as necessary to equilibrium in a stable solid-liquid system. Capillary rise is described as the result of the internal pressure in the liquid in combination with molecular attraction. Experimental data from laboratory experiments are presented to clarify the mechanism offered to describe capillary rise. L. J. Tison, Belgium

156. **Rich, G. R., Hydraulic transients,** New York, London, Toronto; McGraw-Hill Book Co., Inc., July 1951, x + 260 pp. $7.

Book, which gives approximate solutions for some of the most common nonsteady-flow problems in hydraulic engineering, was written by a practical engineer for practical engineers. This becomes apparent from the organization of the subject matter according to the application. The book is outstanding in its clear description of the approximate solutions and in the large number of practical examples. Some readers may have some difficulty in following the author up to the derivation of the equations which he very elaborately solves.

Problems solved are: Water hammer in a pipe line; turbine speed regulation; stability of governing; water hammer in pump discharge lines; the differential surge tank; the restricted orifice surge tank; navigation locks; surges in canals—tidal harmonics. In handling the two last problems, which are open-channel applications, author is not as convincing as in the first six. He does not make good on the thesis that analytical methods as given in his book might replace to some extent the model-test approach. A last short chapter on graphical methods does not by any means cover the large possibility of this method.

H. A. Einstein, USA

157. **Foltýn, V., Cavitation tests of an eight-blade prototype of the Kaplan hydraulic turbine** (in Czech), *Strojirenstvi* **1,** 7–8, 273–278, Aug. 1951.

After short theoretical introduction, author describes cavitation tests on a prototype of Kaplan turbine carried out by the factory CKD-Blansko (Czechoslovakia) for the head of 60 m. Some improvements of the draft-tube immediately after the runner were needed and satisfactory results were obtained.

Miroslav Nechleba, Czechoslovakia

158. **Pielemeier, W. H., Some effects of cavitation near 30 cps,** *J. acoust. Soc. Amer.* **23,** 2, 224–228, Mar. 1951.

Author presents interesting comments on other work in the field. The experimental work presented is very preliminary in nature. E. Fred Macks, USA

159. **Bouvard, M., and Molbert, J., Graphical method for calculating surge tanks** (in French), *Houille blanche* **5,** 5, 535–554, Sept.-Oct. 1950.

Method described by authors introduces a representative plane with coordinates Q (discharge through the tunnel) and Z (water level at the surge tank); increments ΔQ and ΔZ are computed for successive increments of time Δt. Practical working rules and examples are given, including Y-shaped and V-shaped tunnels [cf. also commentary by Ch. Jaeger and authors' reply in *Houille blanche*, Mar.-Apr., pp. 166–168, 1951].

A. Craya, France

Incompressible Flow: Laminar; Viscous

(See also Revs. 153, 178, 183, 186, 198, 199, 214, 215, 236, 277, 278, 279, 298, 319)

160. **Binder, R. C., Advanced fluid dynamics and fluid machinery,** New York, Prentice-Hall, Inc., June 1951, x + 426 pp. $8.

This volume provides the basis of a second undergraduate course in fluid mechanics and, as such, is an extension and yet independent of the author's first course text, "Fluid mechanics." These companion volumes are written in the same simple and straightforward style with expert blending of theory and experiment so valuable to both the student and the practicing engineer. Theoretical developments are minimized to the extent that, in some cases, use of one or more of the Selected References included at the end of each chapter becomes necessary. Physical concepts and results of developments as expressed in quantitative relationships are stressed. The text contains no problem examples but a few good suggested problems with answers which are included at the end of most of the sixteen chapters. The subject matter is basic and, in reviewer's opinion, consists of material that should be included in all mechanical engineering undergraduate curricula in order to provide a suitable foundation for industrial work or advanced studies.

Book is divided into three parts. The first part includes a brief review of fundamentals so that reference to elementary texts is unnecessary. Steady one-dimensional compressible flow of an

ideal fluid (reversible adiabatic process) and the one-dimensional flow of a real compressible fluid with friction and heat transfer are presented. The most important features of real flow are given an elementary treatment. This includes such subjects as boundary layer, separation, and turbulence. It is regrettable that the general problem does not include preliminary discussion of such effects as heat-pressure gradients, curvature, and heating. The treatment of the theory of turbulence does not include recent work in statistical methods. The combined treatment of fluid flow and heat transfer in a fluid dynamics text is an important feature. Third part continues the work in fluid dynamics into unsteady flow phenomena on a one-dimensional basis, including such applications as acoustics and water hammer. Remainder of this part is devoted to an introduction to hydrodynamics, presenting the general equations of motion for the frictionless case and with a viscous fluid. A few specific applications are discussed. Second part includes fluid machinery and is essentially an application of the principles discussed in the first part applied to this specific field. This section includes a description, principle of operation, basic performance equation, and typical performance curves for such equipment as centrifugal pumps, fans, compressors, fluid couplings, fluid torque converters, jet pumps, and jet compressors. An elementary treatment of turbines for water, steam, and gas is developed. Richard G. Folsom, USA

161. **Dolapchiev, B., Application of N. E. Kochin's methods to the investigation of the state of equilibrium of vortex streets** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **78,** 1, 29–32, May 1951.

The stability of a two-parameter vortex street is investigated in first approximation, following Kochin's definition, in which any translatory motion of the street as a whole is considered as an equilibrium state. Condition $\mathrm{sh}\kappa\pi = \sin\lambda\pi$, that for $\lambda = 1/2$ is von Kármán's one, is justified as defining the least unstable configuration. Gino Moretti, Argentina

162. **Tomotika, S., Hasimoto, Z., and Urano, K., The forces acting on an aerofoil of approximate Joukowski type in a stream bounded by a plane wall,** *Quart. J. Mech. appl. Math.* **4,** part 3, 289–307, Sept. 1951.

Using proper transformation function, the two-dimensional flow past two circles is mapped into flow past a system of real and image airfoils placed in unbounded stream. The modification due to the finite thickness and camber of approximate Joukowsky airfoil on the ground effect is investigated. It is found that the rate of increase of the lift due to the presence of the ground becomes smaller as the thickness or camber of the airfoil increases. G. V. R. Rao, USA

163. **Rapoport, I. M., On the plane jet flow of an ideal fluid about a solid body** (in Russian), *Ukrain. mat. Zh.* **2,** 107–117, 1950.

The author considers a class of symmetric two-dimensional free streamline flows which can be used to approximate other flows of this sort. The case of an obstruction in the form of an arc with end points as separation points and also the case of a closed curve with unknown separation points are considered. Let the z-plane (the physical plane) be mapped conformally onto the ζ-plane with a cut along the positive real axis so that the ends of the obstructing arc map onto the points $1 \pm 0i$. Then $d\zeta/dz = Cv$, where $v = v_x - iv_y$ (the complex velocity) and C is a real constant. The author considers the flows obtainable from

$$v(\zeta) = \frac{v_\infty \zeta^{1/2}}{(\zeta - 1)^{1/2} + i} \exp i[\zeta^{1/2}P(\zeta) - (\zeta - 1)^{1/2}Q(\zeta)]$$

where $P(\zeta)$ and $Q(\zeta)$ are polynomials with real coefficients and related by $Q(\zeta) - (1 - \zeta)^{1/2}P(\zeta) = O(\zeta^{-1})$ as $\zeta \to \infty$. With such a choice of v it is possible to satisfy the boundary conditions of the hydrodynamic problem, although the problem of the closed curve is somewhat more elaborate than the arc with end points. Approximations are carried out in the Z-plane, where $Z = Ke^{i\varphi}$, K the curvature, and φ the angle between the tangent to the arc and the imaginary axis. J. V. Wehausen, USA

164. **Evdokimova, V. A., First phase of nonstationary radial filtration of fluids** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **74,** 4, 669–671, Oct. 1950.

Two formulas, one a generalization of D'Arcy's law, the other expressing material balance, are combined. A table shows physical constants to be used when gases, compressible liquids, or incompressible liquids in a gravitational field flow radially between circular boundaries $R_c \leqslant R \leqslant R_k$. Relation between time t and R_k is found for cases when the boundary R_c is at constant pressure, and when the flow is constant. R. E. Gaskell, USA

165. **Roesler, F. C., On the cavitation phenomena in turbulent mixing zones, especially on the boundary of fast liquid jets** (in German), *Öst. Akad. Wiss. math-nat. Kl. Anz.* **87,** 287–290, 1950.

The pressure fluctuations in the turbulent mixing zone of a jet are shown to be proportional to the square of the velocity of the jet. Statical pressure in the jet is independent of jet velocity. It is possible for sufficiently high values of jet velocity to obtain, incidentally, pressure fluctuations, which reduce the total pressure to zero (or the saturation pressure of the vapor). Hence, at high velocities of a fluid jet cavitation, bubbles in the mixing zone may occur. R. Timman, Holland

166. **Delval, J., Principle of smallest constraint applied to dynamics of incompressible fluids** (in French), *Bull. Acad. roy. Belg. Cl. Sci.*, (5) **36,** 8–9, 639–648, 1950.

The author states that, through use of the Eulerian variables, one can derive the equation of flow of an incompressible fluid by applying Gauss' principle in the case of a perfect fluid or of a viscous fluid. Helmholtz' equations can also be derived by an analogous principle. Reviewer's comment: Some indication of the not inconsiderable amount of literature on the application of variational methods to hydrodynamics would have been desirable. Max A. Heaslet, USA

167. **Wilson, L. H., Sibbitt, W. L., and Jakob, M., Flow of gases in porous media,** *J. appl. Phys.* **22,** 8, 1027–1030, Aug. 1951.

The theoretical equations for viscous slip and free molecule flow in tubes are used to derive a semi-empirical formula for similar types of flow in porous media. Fair agreement is obtained with experimental results. From the latter, in conjunction with the theory, it is possible to calculate the mean pore diameter of the tested samples. G. M. Lilley, England

168. **Nevzglyadov, V. G., Flow of a viscous fluid around a plate** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **77,** 5, 795–798, Apr. 1951.

Author solves Oseen equations for slightly viscous fluid flow past a finite plate. Boundary conditions are investigated a small distance $\pm\lambda$ above and below the plate where $Re\lambda^2 \approx 1$, Re being the Reynolds number based on plate length and assumed large, so that equations may be taken linear without undue error. The conditions on the transversal component are satisfied far downstream, while those on the longitudinal component are satisfied at the plate midpoint. The resulting drag coefficient is $c_x = 1.17/Rx^{1/2}$ in good qualitative agreement with Blasius. Paper is

somewhat similar to work of Lagerstrom group [AMR **4**, Rev. 1681]. Leon Trilling, USA

169. **Toraldo di Francia, G., Uniform motion of a viscous fluid container between two rotating concentric spheres** (in Italian), *Boll. Un. mat. ital.* (3) **5**, 273–281, 1950.

Author considers the motion of a viscous incompressible fluid contained between two concentric spheres when the inner one rotates with a constant angular velocity ω and the outer one is fixed. Making use of a successive approximations method, he carries through to the third approximation the computation of the torque on the outer sphere, this being given as a function of R_1/R_2 and a Reynolds number $\omega R_2^2/\nu$ where R_1 and R_2, are radii of the inner and outer sphere, respectively, and ν is the viscosity. Previous approximations had not been carried so far and had shown disagreement with experimental results.

J. V. Wehausen, USA

170. **Schlichting, H., and Truckenbrodt, E., The flow around a rotating disc in a uniform stream,** *J. aero. Sci.* **18,** 9, 639–640, Sept. 1951.

Note in Reader's forum. More details will be published shortly.

Compressible Flow, Gas Dynamics

(See also Revs. 195, 230, 236)

171. **Ferrari, C., The body and the ogival contour giving minumum wave drag** (in Italian), *Atti Accad. Sci. Torino* **84,** 1, 3–18, 1949–1950.

Author rejects, as being unrealistic, the type of approximation made by Sears and by Lighthill in obtaining body shape of minimum wave drag in supersonic flow; arguments against use of very slender body theory stem mainly from unacceptable anomaly that their result does not depend on Mach number. He returns to his paper of a decade ago ["Sulla determinazione del proietto di minimum resistenza d'onda," title source, **74, 75,** July-Dec. 1939, and British R.T.P. Transl. no. 1180] and shows how that treatment does depend on Mach number; in addition, it is now improved to give a closed form solution (although linearization of the equation of motion is still premised). Numerical example is supplied; it turns out that contour for minimum drag is not symmetric fore and aft. Same start and style of attack are made on problem of best ogival nose contour. Shape elicited has as much danger of improper interpretation for purposes of practical design as von Kármán's earlier definition of best ogive shape (which has 4 times drag of new profile, but strict requirement that slope of ogive be horizontal at base). Amusing result of pushing von Kármán criterion to its (il)logical grotesque design consequence was capriciously treated by A. Buseman in "Heutiger Stand der Geschoss Theorie," *Lilienthal-Gesellshaft,* Ber. **139** (translated as Navy CGD no. 406, "Present status of missile theory"). In mitigation of this same danger, author now supplies practical design use for his result by suggesting a comparison procedure with suitable cone. R. H. Cramer, USA

172. **Bureau of Ordnance, Handbook of supersonic aerodynamics, vols. 1, 2,** Super. Doc., U. S. Gov. Ptg. Office, Washington, D. C., Navord Rep. 1488, iv + 334 pp., 226 pp., 1950.

To many readers of AMR this is not a new book. The first edition, prepared by the Aerodynamics Group of the Applied Physics Laboratory of The Johns Hopkins University, was distributed in 1946.

The present edition, consisting of the first five sections (of the contemplated 21 sections), is published in two volumes. The handbook contains short outlines of basic theory and results of the more significant wind-tunnel tests in the form of tables and charts.

Even in the present incomplete form the handbook presents, in a systematic manner, a great deal of data indispensable to a worker in the field of applied supersonic aerodynamics.

A. Petroff, USA

173. **Riabouchinsky, D., On steady almost uniform subsonic, sonic, and supersonic flows** (in French), *C. R. Acad. Sci. Paris* **232,** 4, 280–283, 1951.

For the linearized velocity potential equation

$$(1 - M^2)\partial^2\varphi/\partial x^2 + \partial^2\varphi/\partial y^2 + \partial^2\varphi/\partial z^2 = 0,\ 0 < M < \infty$$

author considers solutions $\varphi = x + \alpha f(x, y, z)$ (α^2 negligible) based on plane wave solutions

$$f = (M^2 - 1)^{-1/2}\sum[\mathfrak{F}_\nu(\zeta) - \mathfrak{F}_\nu(\bar{\zeta})] + \sum[\mathfrak{F}_\mu(\zeta) + \mathfrak{F}_\mu(\bar{\zeta})]$$

for arbitrary functions $\mathfrak{F}_\nu$, where

$$\zeta(\text{or } \bar{\zeta}) = x + (\text{or } -)(M^2 - 1)^{1/2}(a_{1\nu}y + a_{2\nu}z)$$

and $a^2_{1\nu} + a^2_{2\nu} = 1$. Let

$$f_i = -\sum a_{i\nu}[\mathfrak{F}_\nu(\zeta) + \mathfrak{F}_\nu(\bar{\zeta})] - (M^2 - 1)^{1/2}\sum a_{i\mu}[\mathfrak{F}_\mu(\zeta) - \mathfrak{F}_\mu(\bar{\zeta})]$$

where $i = 1, 2$, and let $\psi_1 = y + \alpha f_1$, $\psi_2 = z + \alpha f_2$. To the first order in α, $\psi_i = \text{const}$ are stream sheets, and $x = \varphi - \alpha f(\varphi, \psi_1, \psi_2)$, $y = \psi_1 - f_1(\varphi, \psi_1, \psi_2)$, $z = \psi_2 - \alpha f_2(\varphi, \psi_1, \psi_2)$ is a parametric representation of the flow. As $M \to 1$, $\frac{1}{2}f \to \sum(a_{1\nu}\psi_1 + a_{2\nu}\psi_2)d\mathfrak{F}_\nu(\varphi)/d\varphi + \sum\mathfrak{F}_\mu(\varphi)$, etc. Such a "sonic" flow along wavy cylindrical wall has been constructed by starting from $f = (\cos\zeta - \cos\bar{\zeta})/(M^2 - 1)^{1/2}$. Considering the inadequacy of the linearized equations for description of transonic flow, reviewer believes the passage to the limit $M = 1$ to be of merely formal interest.

Courtesy of Mathematical Reviews J. H. Giese, USA

174. **Hilton, W. F., High-Speed aerodynamics,** New York, London, Toronto; Longmans, Green & Co., Apr. 1951, ix + 598 pp. $8.50.

Book is addressed to aircraft designers who are confronted with problems arising in the transonic and supersonic speed ranges due to shock-wave effects. It is ideally suited to their needs. However, it is not considered suitable as a textbook since it contains not a thorough development of the topics introduced but rather a collection of design criteria.

The first eight chapters (Section I) are devoted to transonic flows. "Shock stall" is defined and its effects on drag, lift, pressure distribution, moment, stability, and control are discussed. Methods are indicated for calculating these effects and for measuring them experimentally. The book is well documented with experimental data and great emphasis is placed on wind-tunnel experimentation for evaluation of design ideas. The transonic section closes with a description of numerous devices for measurement of pressure, Mach number, and inclination of high-speed flows.

The second major section of the book, chapters 8–13, deals with supersonic and hypersonic flows. The Ackeret, Busemann, and "exact" two-dimensional wing theories are presented, and their limitations and accuracies are pointed out. The chapter on linearized theory of flow over three-dimensional wings is preceded by a useful chart giving lift and wave-drag coefficients for various wing planforms. The aerodynamic characteristics of

supersonic fuselages are treated by means of the von Kármán-Moore and Taylor-Maccoll theories. The section is concluded with a chapter on hypersonics (flow at very high Mach numbers) and superaerodynamics (flow at very low densities).

The third section, entitled "High-speed wind tunnels," is a complete exposition of wind-tunnel design and operation, both subsonic and supersonic, and reflects the author's extensive experience in this field. Much attention is devoted to methods of measurement as well as to the design of the tunnel best suited to the aerodynamic problems encountered. Limitations as well as advantages of wind-tunnel experimentation are presented. This section is outstanding and should be of great value to all workers in the field.

Book concludes with a general section containing chapters on thermodynamics (including derivations of shock-wave relations), propellers, jet propulsion, unsteady flow at sonic speeds, and elementary low-speed aerodynamics.

All subjects are well illustrated. Numerous design charts will appeal to the aircraft designer. Likewise, the emphasis on the experimental approach and the excellent section on wind tunnels will interest the experimenter. The theorist, however, is understandingly overlooked in a book of this type.

Lester L. Cronvich, USA

175. **Wood, G. P., and Gooderum, P. D., Method of determining initial tangents of contours of flow variables behind a curved, axially symmetric shock wave,** *Nat. adv. Comm. Aero. tech. Note* 2411, 44 pp., July 1951.

A method is given of calculating initial tangents of contours of constant density, pressure, Mach number, and entropy (streamlines) at a curved axially symmetric shock wave whose location and shape are known. Method is based on equation for pressure jump across an oblique wave as well as on Bernoulli and continuity equations and relation between curvature of a streamline and cross-sectional area of stream tube. Calculations are carried out for the interferograms of the supersonic flow around a sphere obtained previously by authors [AMR **4**, Rev. 2577]. The calculated tangents are found to fit the constant density contours obtained by interferometry. Calculations are also made by means of method of characteristics [Ferri, *NACA Rep.* 841, 1946] and qualitative agreement with the contours obtained from the interferogram is found. Morris Morduchow, USA

176. **Perry, R. W., and Kantrowitz, A., The production and stability of converging shock waves,** *J. appl. Phys.* **22**, 7, 878–886, July 1951.

Authors have developed a technique for producing converging cylinder shock waves in a shock tube in such a way that region of convergence is relatively well isolated thermally from the walls. By this means they have been able to produce very high pressures with temperatures great enough to produce considerable luminosity. Stability of the wave is studied.

Martin D. Schwartz, USA

177. **Cabannes, H., Determination of the shock wave in front of a body of revolution when the velocity at the apex of the obstacle is subsonic** (in French), *C. R. Acad. Sci. Paris* **233**, 5, 354–356, July 1951.

A previous paper [AMR **4**, Rev. 2583] gave the method of calculation of the equation for the shock wave attached to a pointed body, and derived from it the ratio of the radii of curvature at the vertexes of the shock wave and the body. This paper shows briefly how the results may be extended from the case of axially symmetric flow to the more general case of two-dimensional flow. By expressing the shock-wave equation in a power series with nonintegral exponents, it is possible to explain mathematically the paradoxical case of a shock wave which is convex toward the approaching stream at the same time that it is convex toward the tip of the body. Ione D. V. Faro, USA

178. **Coale, C. W., Suction force on the lip of a two-dimensional idealized scoop in non-viscous subsonic flow,** *Douglas Aircr. Co. Rep.* SM-13742, 17 pp., Apr. 1950.

The suction force at the lip of an idealized two-dimensional scoop is found by the law of momentum; the location of the stagnation point by means of complex variables.

Gottfried Guderley, USA

179. **Hasimoto, H., On the subsonic flow of a compressible fluid past a Rankine ovoid,** *J. phys. Soc. Japan* **6**, 3, 175–178, May-June 1951.

Janzen-Rayleigh's method is applied to the calculation of the first approximation of Stokes' stream function of compressible flow past a Rankine ovoid (axially symmetric flow about source and sink of equal strength). One example for thickness ratio 0.9 is calculated. The boundary conditions are satisfied by the compressibility correction term in some selected points only. It is found that, for this ovoid, the effect of compressibility on the velocity is nearly equal to that of a sphere, a fact which, as the author states, "appears rather surprising." Reviewer notes that results of C. Schmieden ["Die kompressible Strömung um ein Rotationsellipsoid nach der Methode von Janzen-Rayleigh," *Deutschen Luftfahrtforschung*, Jahrbuch 1942, p. 72] show that the effect of compressibility on the velocity about ellipsoids depends considerably on the thickness ratio. Some obvious errors or misprints are in formula (13). Edgar Krahn, England

180. **Weinstein, A., Transonic flow and generalized axially symmetric potential theory,** *Nav. Ord. Lab. Rep.* NOLR-1132, 73–82, 1950.

A transonic flow may be described approximately by Tricomi's equation (1) $\sigma\psi_{\theta\theta} + \psi_{\sigma\sigma} = 0$, where ψ is the stream function and σ, θ appropriate hodograph variables. For $\sigma < 0$, (1) may be written in characteristic coordinates as (2) $(\eta^k\psi_\xi)_\xi + (\eta^k\psi_\eta)_\eta = 0$ (with $k = 1/3$). The author studied equation (2) in a previous paper [*Trans. Amer. math. Soc.* **63**, 342–354, 1948], interpreting ψ as a rotationally symmetrical solution of the Laplace equation in a $(k + 2)$-space. The resulting formulas are valid for nonintegral k. Thus, author obtains a fundamental solution of (1) in the form (3) $\psi_b(\xi, \eta) = \pi^{-1}b^{1/2}\eta^{-k/2}Q_{-k/2}(1 + 2\epsilon^2)$ where Q is a Legendre function of the second kind and $\epsilon^2 = [\xi^2 + (\eta - b)^2]/4b$. Other solutions of (1) with singularities are obtained from (3) by differentiation and integration. All these functions can be continued into the "subsonic" (elliptic) region $\sigma > 0$ without singularities. As an application, a formula is derived representing a subsonic flow past a wedge in a channel which becomes sonic along curves joining the edge walls with the channel walls. Other applications are to be given in subsequent papers.

L. Bers, USA

181. **Schultz-Piszachich, W., Contribution to calculation by formulas of velocity-distribution of concave airfoils in subsonic and supersonic flow** (in German), *Öst. Ing.-Arch.* **5**, 3, 226–240, 1951.

Author develops theory of linearized compressible flow past two-dimensional airfoils from first principles. The potential is expanded in a series of powers of y, with coefficients represented by a series of powers of the thickness parameter. The unknown coefficients in these latter series are determined from the surface boundary condition in the conventional manner. The theory is comprehensive, giving the potential on an airfoil of any shape in

both subsonic and supersonic fields of flow. But the claim that symmetrical profiles only have been considered by earlier writers is surely exaggerated. Since the war, the subject has been treated thoroughly in both Britain and the United States.

Maurice Holt, England

182. Dörr, J., Contribution to a vortex theory of compressible media (in German), *Ing.-Arch.* **18,** 6, 378–384, 1950.

The flow fields of certain vortex systems are calculated for a two-dimensional subsonic compressible medium. Systems investigated correspond to the bound vortex with variable lift, the bound vortex with constant lift, and the bound vortex moving harmonically. Finally, the integral equation for the pressure distribution of an oscillating plate is given.

H. P. Liepman, USA

183. Grace, H. P., and Lapple, C. E., Discharge coefficients of small-diameter orifices and flow nozzles, *Trans. Amer. Soc. mech. Engrs.* **73,** 5, 639–647, July 1951.

Calibration of orifice metering equipment was undertaken with air and water flows to establish performance and reliability for a wide range of small flow rates. Discharge coefficients as a function of Reynolds number for knife-edged orifices of $^1/_{32}$-in. to $^3/_4$-in. diam in a standard 1-in. pipe were determined within $\pm 0.5\%$. Thick-plate orifices (one hole diam thick) in the same size range did not give reproducible results, particularly the smaller sizes. When used under critical flow conditions, the thick-plate orifices (tested up to $^1/_4$-in. diam) were as good or better than nozzles with respect to constancy of discharge coefficients, while knife-edged orifices were poor in this respect.

J. S. Isenberg, USA

184. van den Dungen, F. H., Note on the Hamel-Synge theorem, *Quart. appl. Math.* **9,** 2, 203–204, July 1951.

Extension of Synge's theorem [AMR **4,** Rev. 1680] to a three-dimensional motion. Ed.

185. Loitsianskii, L. G., Generalization of Joukowski formula to an airfoil of a cascade in compressible gas stream with subsonic velocites, *Nat. adv. Comm. Aero. tech. Memo* 1304, 16 pp., Sept. 1951.

See AMR **3,** Rev. 535.

186. Loitsianskii, L. G., Resistance of cascade of airfoils in gas stream at subsonic velocities, *Nat. adv. Comm. Aero. tech. Memo* 1303, 30 pp., Sept. 1951.

See AMR **3,** Rev. 942.

187. Herzberg, A., Shock tubes for hypersonic flow, *Cornell Aero. Lab. Rep.* no. AF-702-A-1, 7 pp., 5 figs., May 1951.

Paper concerns adaptation of the shock tube to the study of hypersonic flows. Method proposed consists of expanding the tube on the low pressure side of diaphragm, thereby permitting the high-temperature air upstream of the shock front (created by removing the diaphragm) to accelerate from low to high supersonic airspeeds. A Mach number of 4.2 was obtained, as predicted, in a small shock tube of this design. Reviewer believes use of shock tube as proposed by author to be a promising method for obtaining short-duration hypersonic flows at essentially free-flight stagnation conditions, particularly as regards temperatures.

Alfred J. Eggers, Jr., USA

188. Saito, O., On some exact solutions of the two-dimensional steady flow of compressible fluid, *J. phys. Soc. Japan* **6,** 4, 248–256, July-Aug. 1951.

In the usual meaning let u, v be velocity components along x, y axes; q, Θ polar coordinates in (u, v)-plane; ϕ, ψ velocity potential, stream function, respectively; ρ density, c velocity of sound and $w \equiv \Theta \int \rho q^{-1} dq$; then author obtains:

$$\phi_\psi + \Theta_w = 0, \quad \phi_w \Theta_\psi - \phi_\psi \Theta_w = q \frac{d}{dw} (\rho q)^{-1}$$

for the differential equations of two-dimensional steady flow of a compressible fluid by taking q and ψ as independent variables. With $\phi \equiv F_w$, $\Theta \equiv -F_\psi$ the first equation will be satisfied automatically, and the second may be transformed in

$$F_{ww} F_{\psi\psi} - (F_{w\psi})^2 = \rho^{-2}(1 + d\rho/dw) = f(w) \qquad [*]$$

For adiabatic flow ($f(w) = \rho^{-2}(1 - q^2 c^{-2})$) and under the assumption that [*] possesses an intermediate integral, author gets in supersonic flow ($q \geqslant c$)

$$F = \pm \psi \int \rho^{-1}(q^2 c^{-2} - 1)^{1/2} dw + A\psi + g(w) \qquad [**]$$

where $g(w)$ is an arbitrary function and A an arbitrary constant; and in subsonic flow ($q < c$)

$$F = (\psi + C)^2 (Aw + B)^{-1} + \tfrac{1}{2} \int dw \int (Aw + B) f dw + D\psi + Ew + G \qquad [***]$$

where $A, \ldots, G$ are arbitrary constants. These two expressions lead to explicit formulas for ϕ, Θ and therefore also to x, y by quadratures. In taking a series $\sum_{\nu=0}^{n} \alpha_\nu(w) \psi^\nu$ as F, then [*] is satisfied when $n = 1, 2$, and ∞. The case $n = 1$ coincides with [**], and $n = 2$ with [***]. The case $n = \infty$ will be discussed in a later paper.

H. Bilharz, Germany

189. Kawaguchi, M., Application of the M^2-expansion method to the compressible flow past an elliptic cylinder, *J. phys. Soc. Japan* **6,** 3, 168–174, May-June 1951.

Author applies a formula, worked out by Imai by the Rayleigh-Janzen method for the velocity distribution on an arbitrarily shaped body in a uniform compressible two-dimensional flow, to the case of an elliptic cylinder at zero angle of attack. This formula carries the approximation to the M^4 term and author exhibits the results of numerical examples for cylinders of thickness ratios of 0.1 and 0.5 for Mach speeds 0.7, 0.8, and 0.5, respectively. Detailed algebraic work is presented. Graphical comparisons are made with the results of other methods, and it is shown that the M^4 term approximation results in a reduction of critical Mach speed of about $2^1/_2\%$.

M. G. Scherberg, USA

190. Oswatitsch, K., Similarity laws for hypersonic flow (in German), *Z. angew. Math. Phys.* **7,** 4, 249–264, July 1951.

Author shows that as free-stream Mach number increases indefinitely, the inviscid flow field about an arbitrary three-dimensional object eventually approaches a stationary flow in the sense that geometry of bow wave, streamlines, and Mach lines becomes independent of further increases in free-stream Mach number. This limiting type of flow, which is termed "hypersonic," requires that the free-stream Mach angle be small compared to the incidence angle of the body surface. For such a flow, pressure coefficients on surfaces facing upstream are independent of Mach number, and for slender bodies are proportional to square of incidence angle irrespective of body shape. For slender bodies, theory applies only at extremely high Mach numbers.

Author's definition of hypersonic flow differs from the more common definition first formulated by Tsien. Corresponding similarity rules also differ. It appears that author's concept of

hypersonic flow is essentially the same concept as that referred to in English literature as Newtonian flow, although this is not discussed in paper. Dean R. Chapman, USA

191. **Kantrowitz, A., and Grey, J., A high intensity source for the molecular beam. Part I. Theoretical,** *Rev. sci. Instrum.* 22, 5, 328–332, May 1951.

The design of a high intensity source for molecular beam is outlined. The gain in intensity (by a factor of 75 for sample design) of proposed over conventional method is obtained by placing the first slit in a high-speed stream of rarefied gas produced by a supersonic nozzle. Difficulties have been experienced by the reviewer and others in the production of high Mach number flows of a rarefied gas by the use of small scale nozzles. The difficulty appears to be due to the rapid boundary-layer build-up on the nozzle walls at the very low Reynolds numbers involved. In addition to the suggested boundary-layer correction applied to the nozzle walls, boundary-layer removal by suction through porous walls has been found helpful. Glen Goodwin, USA

192. **Klyachkin, A. L., Isothermal flow of gas in a cylindrical pipe** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **73,** 3, 467–570, July 1950.

Paper gives some relations resulting from the one-dimensional equation of motion, the equation of continuity, and the first law of thermodynamics (with heat introduced from outside and heat derived from friction). They are applied to the case T = const along the tube. The presence of a factor $(1 - kM^2)$, where M = Mach number and $k = c_p/c_v$, points to a critical condition when $M = k^{-1/2}$. Expressions are given for the heat introduced over a certain length of the tube. J. M. Burgers, Holland

Turbulence, Boundary Layer, etc.

(See also Revs. 165, 232, 235)

193. **Kuerti, G., Boundary layer in convergent flow between spiral walls,** *J. Math. Phys.* **30,** 2, 106–115, July 1951.

A family of exact solutions of the Navier-Stokes equation discovered by Hamel is such that the streamlines are logarithmic spirals. For one member of this family, viz., the limiting case of convergent flow between radial walls, it has been shown previously that the solution tends, as the Reynolds number becomes infinite, to the corresponding solution of the boundary-layer equation. The task accomplished by the author is to show that the asymptotic forms of Hamel's solutions in all cases of convergent flow between spiral walls are identical with the corresponding solutions obtained from the boundary-layer equation. The proof is not mathematically simple.

G. K. Batchelor, England

194. **Schlichting, H., Boundary-layer theory [Grenzschicht-Theorie]** (in German), Karlsruhe, G. Braun, 1951, xv + 483 pp., 295 figs., 32 tables. $10.

Beginning with the classical paper of Prandtl in 1904 on the motion of fluids of very small viscosity, a rational approach to the understanding of many phenomena encountered in the motion of air and water has been developed in terms of the boundary-layer concept. Development of boundary-layer theory and experiment was, at first, carried out by Prandtl's students at Göttingen, among them Prof. Schlichting; but beginning in the 1920's, English and American investigators also contributed importantly to further advances. Comprehensive summaries were given by Tollmien in 1931 in "Handbuch der Experimentalphysik," and by Prandtl in 1935 in "Durand's aerodynamic theory." The current book by Schlichting is particularly timely. Its pages contain a wealth of information on the progress of the past fifteen years.

The book is addressed primarily to engineers in the sense that material of application to engineering problems has been selected and emphasis is on physical ideas rather than mathematical refinement. It is an outgrowth of a series of lectures given during the war to physicists and engineers, but these were completely rewritten to include German material previously classified secret and material from other countries. The main emphasis is on theoretical methods of analysis, and only those experiments are included which give physical insight into the phenomena, serve to check the applicability of the theoretical results, or, as in the case of turbulent flow, constitute the foundation of a semi-empirical theory.

Four main topics are covered, namely, the fundamentals of flow of a viscous fluid, laminar boundary layers, transition, and turbulent boundary layers. The inclusion of the first topic, occupying 89 pages, makes the book entirely self-contained, since a brief account is given of the basic concepts of the motion of viscous fluids, and of the development, general properties, and exact solutions of the Navier-Stokes equations. The section on laminar boundary layers (182 pages) includes two-dimensional, axially symmetric, and three-dimensional boundary layers, exact and approximate solutions, nonstationary boundary-layer flow, boundary-layer control, and thermal boundary layers in incompressible and compressible flow.

Transition is treated in two chapters (59 pages) entitled "Origin of Turbulence I and II." This section is essentially an extensive account of the theory of the stability of the laminar boundary layer and its experimental verification, with no specific contribution to the problem of the development of turbulence from the amplified boundary-layer oscillations.

A discussion of turbulent flow from the point of view of the mixing-length theory occupies the remaining 145 pages. Flows in pipes, along flat plates with and without pressure gradient, near rotating disks, and in wakes and jets are included, together with one chapter on the determination of profile drag. The modern statistical theory of turbulence has purposely been omitted since it has not yet led to useful engineering application.

Hugh L. Dryden, USA

195. **Hayes, W. D., The three-dimensional boundary layer,** *U. S. nav. Ord. Test Sta. Inyokern tech. Memo* RRB-105, ii + 46 pp., 1950.

For three-dimensional laminar boundary-layer flows of compressible and viscous fluids over smooth boundary surfaces, the equations of motion in curvilinear coordinates of the following cases are given: (a) The body of revolution; (b) cylindrical flow; (c) conical flow; and (d) streamline coordinates. It is shown that, except (b), all the cases considered cannot be generally reduced to two-dimensional problems, but do admit solutions by an iteration method when the cross flow is small. For case (d), the method of linearization of the cross-flow equation is briefly discussed. Finally, the integral forms of the equations are also presented. Y. H. Kuo, USA

196. **Deissler, R. G., Analytical investigation of fully developed laminar flow in tubes with heat transfer with fluid properties variable along the radius,** *Nat. adv. Comm. Aero. tech. Note* 2410, 18 pp., 10 figs., July 1951.

Author assumes: (1) Axial velocity is independent of distance along the tube; (2) radial temperature gradient is independent of z; (3) energy dissipation due to friction is negligible; (4) viscosity, thermal conductivity, and density vary with temperature,

but specific heat and Prandtl number are constant; (5) heat transfer by conduction in the direction along the tube is negligible.

A relation is derived in terms of dimensionless variables from which the temperature profile at any section of the tube can be computed by an iteration process, provided temperature at the wall and radial temperature gradient at the wall are known at the section in question. The velocity profile can then be found. Cases of ideal gases, liquid metals, and a fluid with constant properties are discussed.

Reviewer believes that justification of the far-reaching assumptions made (particularly assumption 2) is necessary.

George W. Morgan, USA

197. **Eckert, E. R. G., and Soehngen, E., Interferometric studies on the stability and transition to turbulence of a free-convection boundary layer,** Gener. discuss. heat transfer, Lond. Conf., Sept. 11–13, 1951. Sect. IV. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs., 3 pp., 1951.

Experimental results obtained by a Zehnder-Mach interferometer to study the free-convection boundary layer on heated vertical plate of 3-ft height are reported. Near the leading edge of the plate up to 15 to 20 in., the boundary layer is laminar. Beginning at a distance of 15 to 20 in., Tollmien-Schlichting oscillation waves start to appear. The wave length of the first amplified oscillation was found to be $\lambda = 3.1\ \delta$, where δ is the boundary-layer thickness, which is smaller than Tollmien's theoretical value of for the forced-flow boundary layer on a flat plate. The critical Grashof number was found to be 4×10^8. Further downstream these oscillations are amplified and become quite irregular and peculiar.

Some instantaneous temperature profiles are given.

Two interference photos for the flow near the fully developed turbulent region are shown which give some qualitative results about the turbulent fluctuations in free-convention boundary layer on a plate. S. I. Pai, USA

198. **Okabe, J., The vorticity in the laminar boundary layer of a surface of revolution,** *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **6,** 2, 47–51, Jan. 1950.

A diffusion equation for a quantity related to the azimuthal vorticity component in axisymmetric, boundary-layer flow is set up by a Boussinesq-like transformation to coordinates depending on the potential and stream function of the potential flow approximation. Two agreeing solutions of the boundary layer are found by determining vorticity, and vorticity-source distributions on the body surface. A. F. Pillow, Australia

199. **Kurihara, M., A new interpretation of mixture length theory in view of energy relation and turbulent flow in a pipe,** *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **6,** 2, 13–21, Jan. 1950.

A parameter $\epsilon(y)$ is introduced which indicates the ratio of the rate of generation to the rate of dissipation of kinetic energy of turbulence. In addition, it is assumed that the mixing length expression derived by Taylor for isotropic turbulence can be applied to boundary-layer flow if it is modified by multiplying by a function $\psi(y)$ such that the product $\epsilon(y)\ \psi(y)$ is a constant through the boundary layer. An expression is then derived for the mean velocity distribution which can be fitted to Nikuradse's measurements in the inner portion as well as the outer portion of the turbulent boundary layer. Gerald E. Nitzberg, USA

200. **Kurihara, M., The statistical mechanics of turbulence based on the new definition of turbulence and Maxwell-Boltzmann's distribution law of velocities,** *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **6,** 2, 9–12, Jan. 1950.

Author defines the statistical properties of a turbulent motion in terms of the statistical history of a large number of "representative particles" of the fluid, and purports to find that, in the case of steady turbulence, Liouville's theorem applies to the phase space of the system of particles. In second part of paper, author shows that the velocity of any particle in isotropic turbulence is normally distributed, although in reviewer's opinion the "proof" establishes consistency only and not necessity. Paper is too abbreviated to make critical perusal possible.

G. K. Batchelor, England

201. **Kurihara, M., A new definition of turbulence based on the theory of probability and the fundamental equations,** *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **6,** 2, 6–8, Jan. 1950.

Author obtains an equation, analogous to the Boltzmann equation, for the variation of the probability density function of any of the physical quantities associated with a fluid in turbulent motion. G. K. Batchelor, England

202. **Kurihara, M., On turbulent viscosity,** *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **6,** 2, 40–41, Jan. 1950.

Brief account of longer paper (in Japanese) on statistical theory of turbulence. G. K. Batchelor, England

203. **Altman, J. M., and Hayter, N.-L. F., A comparison of the turbulent boundary-layer growth on an unswept and a swept wing,** *Nat. adv. Comm. Aero. tech. Note* 2500, 30 pp., Sept. 1951.

Measurements were made of the turbulent boundary layer of a two-dimensional unswept wing and comparable 45° swept wing.

For zero lift, the boundary-layer displacement thickness, momentum thickness, and shape parameters based on the component of velocity normal to the leading edge of the swept wing were in good agreement with the same parameters for the unswept wing. However, for the wing at moderate lift coefficient, the growth of the boundary-layer component normal to the leading edge was more rapid on the swept wing than on the unswept wing. This result may have been due to the difference in surface conditions on the two models. Authors supported this belief by a check which showed that the growth of the momentum thickness on the swept wing, calculated in accordance with simple sweep theory by using the component of flow normal to the leading edge, was in good agreement with the measured growth.

Bernard W. Shaffer, USA

204. **Goldstein, S., On the law of decay of homogeneous isotropic turbulence and the theories of the equilibrium and similarity spectra,** *Proc. Camb. phil. Soc.* **47,** part 3, 554–574, July 1951.

Paper consists of three parts. In the first, author gives an extension of Kolmogoroff's theory assuming the basic hypothesis that statistical properties of the isotropic turbulence are not only function of dissipation ϵ of energy per unit volume and viscosity ν, but also of the time rate of change ϵ_t. This hypothesis requires less restrictions about Reynolds number than Kolmogoroff's original hypothesis, and from it follows that some quantities, given according to Kolmogoroff's theory as universal constants, are functions of turbulence Reynolds number, defined as: $R = (\mathbf{u}^2 t)_{t=0}/\nu$. Lin's decay law logically follows from the extended hypothesis.

In the second part, author states "equilibrium-spectrum" relations according to Heisenberg's, Obukhov's and Kovasznay's assumptions about the "transfer term" in energy equation, and derives some explicit formulas for the validity of the spectrum.

In the third part, author considers Heisenberg's theory of the similarity spectrum and shows that Lin's law can be derived from

an extension of Heisenberg's theory, based on the hypothesis that dissipation ϵ, and not energy, is given by the similarity spectrum, and that similar statistical processes for energy-dissipating eddies are governed by dissipation ϵ and by its time variation, not by energy and time. Author believes, however, that a further generalization of the theory of similarity spectrum is necessary and proposes a more general decay law $\mathbf{u}^2 t = \nu R d(t)$ where $d(t)$ is an integral function of t such that $d(0) = 1$. The function $d(t)$, and the number of constants needed to approximately specify it depend probably on initial conditions. Author suggests an experiment to check the dependence of the decay law on said initial conditions. Carlo Ferrari, Italy

205. **Goldschmied, F. R., Skin friction of incompressible turbulent boundary layers under adverse pressure gradients,** *Nat. adv. Comm. Aero. tech. Note* 2431, 65 pp., Aug. 1951.

Author reviews the available data and correlations for the effects of adverse pressure gradient in turbulent boundary layers in incompressible flow. He concludes that the momentum-balance method for measuring skin friction in adverse pressure gradients is of doubtful value due to its sensitivity to measurement errors and to deviations from flow conditions assumed in the momentum-balance derivation. He shows that the skin-friction results obtained by the momentum method cannot be correlated by one parameter, as claimed by numerous investigators. A new two-parameter correlation is derived from energy-transfer considerations. Furthermore, measurements by the momentum-balance method are shown to indicate an increasing skin friction as separation is approached, while those by X-type hot-wire instruments and by heat-transfer measurements indicate the expected decrease in skin friction as separation is approached. The latter method is thought to be the most reliable.
Carl Gazley, Jr., USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 33, 234, 253, 276)

206. **Laitone, E. V., and Walters, E. R., The application of nonstationary airfoil theory to dynamic stability calculations,** *J. aero. Sci.* **18,** 3, 214–216, Mar. 1951.

The two-dimensional nonstationary airfoil theory of Theodorsen is applied to the determination of three-dimensional stability characteristics by an appropriate axis transformation and finite aspect ratio correction. From authors' summary

207. **Rościszewski, J., Longitudinal dynamic stability of an aircraft flying at high (subsonic) speeds** (in Polish), *Techn. Lotn.* 6, 2, 40–44, June 1951.

Paper is a highly abridged summary of the effect of high speed on longitudinal dynamic stability. Items considered include modification of wing and stabilizer aerodynamic characteristics, as well as aeroelastic effects including flutter.
M. J. Thompson, USA

208. **Kramer, M., Zobel, Th., and Esche, C. G., Lateral control by spoilers at the DVL,** *Nat. adv. Comm. Aero. tech. Memo.* 1307, 82 pp., Aug. 1951.

Translation from ZWB *Forschungsber.* no. 964, 1938–1939.

209. **Wilkinson, K. G., The design of sailplanes for high performance,** *Aircr. Engng.* **23,** 271, 263–271, Sept. 1951.

Author analyzes influence of wing span, aspect ratio, extension of laminar boundary-layer flow, and use of flaps on performance characteristics of single and two-seater sailplanes for thermal soaring. Sinking speed and corresponding forward speed are calculated for minimum rate of descent and best glide ratio. Moreover, interthermal speed and average cruising speed are investigated. Drag data used are based on results of flight tests and wind-tunnel profile measurements; equipped weight is derived by statistical method. Results are shown in graphs from which effectiveness of varying design parameters follows.
L. R. Lucassen, Holland

210. **Slotboom, J. G., Jet planes and their problems** (in Dutch), *Voordr. Konink. Inst. Ing.* no. 33–46, 693–706, July 1951.

The development of modern aircraft, highly stimulated by World War II, tends to high speeds and larger aircraft. Raising the forward speeds, compressibility effects are encountered leading to the formation of shock waves (wave drag), instability of the plane, and a decreased propeller efficiency. The net propulsive power that is needed increases with speed. Hence, very large and heavy motors become necessary. The unfavorable compressibility effects can be avoided up to a rather high Mach number (e.g., 0.80) by using high-speed wing profiles and sweepback (or forward) of the wing. Large propulsive powers can be produced by turbojet engines, which combine their power with small weight and bulk. Some sorts of jet propulsion are discussed briefly, and some photographs of modern jet planes are shown.
From author's summary

211. **Preston, J. H., and Manwell, A. R., Calculation of the interference on a thin symmetrical aerofoil with hinged flap spanning a closed wind-tunnel,** *Aero. Res. Counc. Lond. Rep. Mem.* 2465, 14 pp., 6 figs., 1941, published 1951.

Starting with the solution for the flow due to a vortex between parallel walls, an arbitrary distribution of vortexes is assumed along the chord line of wing and flap in the form of a Fourier series, and the coefficients are determined by satisfying the downwash condition on the chord line, terms higher than the fourth power in the ratio wing chord/tunnel height being neglected. Results are given in the form of graphs for the rates of change of lift coefficient and hinge moment coefficient with incidence and flap setting covering a range of the ratio of control chord/wing chord from 0 to 1.0 and a range of the ratio wing chord/tunnel height from 0 to 0.5. Reviewer feels that a list of notations would have been a desirable addition. A. D. Young, England

212. **Axell, G., Airplane maneuverability** (in Swedish), *Tekn. Tidskr.* **80,** 35, 856–860, Sept. 1950.

Maneuverability (in terms of minimum radius of turn) in the subsonic and supersonic regions is discussed. Basic dynamic relationships in turns are derived. Flight envelope graphs illustrating maximum load factor vs. Mach number are shown, and the manner in which they are obtained is described. Method of obtaining minimum turning radius from flight envelopes and from thrust and drag considerations is explained. In particular, turns with a tangential acceleration are dealt with, and a chart describes such turns. The chart shows (for an initial Mach number of 1.40 and at an altitude of 10 kilometers) the relationship between load factor, angle of turn, duration of turn, radius at the beginning and at the completion of the turn, and Mach number at completion of turn. Finally, some aspects of combat between airplanes at high velocities are mentioned. T. A. Mortensen, USA

213. **Hall, A. H., An experimental study of the static stiffness and deformation of swept wings with uniform chord,** 3rd Anglo-Amer. Aero. Conf., Brighton, Sept. 4–7, 1951, Roy. aero. Soc., 525–544, 1951.

Experimental static bending and torsional deflection data are

given for eleven model untapered swept wings. Angle of sweep varied from $-15°$ to $+60°$ in 15° increments, each sweep angle having models with ribs normal to leading edge and parallel to airstream. Influence coefficients are given from which bending and torsional displacements were calculated for a distributed aerodynamic load at the 25% chord line. Rib direction in root triangle is found to have small influence on effective length in torsion, bending stiffness, and mode of deformation.

W. S. Aiken, Jr., USA

214. Bergrun, N. R., An empirical method permitting rapid determination of the area, rate and distribution of water-drop impingement on an airfoil of arbitrary section at subsonic speeds, *Nat. adv. Comm. aero. tech. Note* 2476, 151 pp., Sept. 1951.

Procedure involves the use of previously calculated water-drop trajectories made on five airfoils at several lift-coefficient values. A differential analyzer was used for the solution of the differential equations, and resulting information was tabulated and plotted into a form which is readily usable once the velocity distribution over an arbitrary airfoil is known. An example of use of the method is carried out in detail for an NACA 23015 airfoil at $C_L = 0.5$, clarifying the procedure by illustrating each step. It is expected that this work will help in the prediction of the usefulness of heated devices. Method has been developed primarily for incompressible flow, but indications of the probable effect of compressibility at a Mach number of 0.6 are also given.

Robert S. Ross, USA

215. Lal, S., Icing of "low-drag" wing sections. I, *J. aero Soc. India* **3,** 1, 11–17, Feb. 1951.

The large drag increase when transition point moves forward due to ice forming around leading edge on a "low-drag" airfoil could be a source of considerable danger. Paper outlines purely theoretical method for estimating icing rate on any arbitrary airfoil section. Movement of water droplets in the velocity field is investigated by extension of Theodorsen's theory of potential flow giving a mapping of velocity components of a region in front of the wing. Equations of motion of water droplets are set up and solved by step-by-step method similar to that due to Bergrun. Trajectories of droplets in path of airfoil are plotted, and limiting trajectories inside which droplets strike wing can be found. Paper concludes with equation for rate-of-catch of water. It is noted that part II of paper will demonstrate application of method.

A. F. W. Langford, Australia

216. Halliday, A. S., Batson, A. S., and Miss Cox, D. K., Wind-tunnel tests on the effect of accretion of ice on control characteristics in two-dimensional flow, *Aero. Res. Counc. Lond. curr. Pap.* 42, 5 pp., 21 figs., May 1950, published 1951.

Results of tests made on an airfoil using simulated ice accretion at the leading edge indicate that control-surface effectiveness can be changed by the presence of ice, and that in some cases a reduction of trailing-edge angle may reduce this adverse effect. Although no definite conclusions are drawn, author does submit his test data and recommends several cautions to the designer.

Robert S. Ross, USA

217. Lehrian, D. E., Calculation of the damping for rolling osillations of a swept wing, *Aero. Res. Counc. Lond. curr. Pap.* 51, 10 pp., Oct. 1950.

Calculations for damping derivatives for rolling oscillations of a rectangular wing and a constant chord sweptback wing, both of aspect ratio 6, are compared with experimental results over a range of reduced frequencies. Theory employed assumes wing and wake are replaced by a doublet distribution such that the boundary condition on downwash at the wing is satisfied at one point on each of several chordwise sections. Good agreement with experimental values is shown when reduced frequency based on roll rate, chord, and free stream velocity exceeds 0.5. Effect of sweepback is found to decrease damping derivative. Disparity between calculated and experimental results for aerodynamic "stiffness" derivative, rolling moment resulting from displacement in roll, is discussed. Theoretical discussion is brief and absence of table of nomenclature necessitates recourse to references.

Ellis Lapin, USA

218. Flügge, W., and Tonski, A., Theory of static tests of airplane wings (in French), *Rech. aéro.* no. 22, 45–53, July-Aug. 1951.

Résumé of report to appear subsequently in *Off. nat. Etud. Rech. aéro.*

219. Pian, T. H. H., Erratum, *J. aero. Sci.* **18,** 9, p. 640, Sept. 1951.

Correction to paper reviewed in AMR **4,** Rev. 1551.

220. Aeroplane and Armament Experimental Establishment Staff, Notes on definitions of and nomenclature for "air speeds," *Aero. Res. Counc. Lond. curr. Pap.* 49, 8 pp., Nov. 1950.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 206, 217)

221. Luke, Y. L., and Dengler, M. A., Tables of the Theodorsen circulation function for generalized motion, *J. aero. Sci.* 18, 7, 478–483, July 1951.

The generalized Theodorsen circulation function

$$C(k) = {}_1\!\int_{-\infty}^{\infty} xU\,dx/(x^2-1)^{1/2}\,/\,{}_1\!\int_{-\infty}^{\infty}(x+1)U\,dx/(x^2-1)^{1/2}$$

$$U = U_0 e^{i[k(s/b-x)+\phi]}$$

$$k = \omega - i\mu;\ \omega > 0$$

is expressed in terms of Hankel functions of complex argument as

$$C(k) = H_1^{(2)}(k)/[H_1^{(2)}(k) + iH_0^{(2)}(k)]$$

Tables are given of the real and imaginary parts of $C(k)$ for different values of ρ and θ, where $\rho e^{i\theta} = k$.

A discussion of the Theodorsen function by W. P. Jones [*Rep. Mem.* no. 2117, Aug., 1945] is shown by the authors to be incorrect and the difficulty is clarified.

Paul Seide, USA

222. Lotkin, O. I., On the application of Galerkin's method to the calculation of an airplane wing in flutter (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **6,** 153–160, 1950.

Galerkin's method is applied to the differential equations of flexural-torsional flutter. Author calculates in detail approximations for the bending and torsion modes, which satisfy the primary and secondary boundary conditions but give only a very short indication of their use in the problem.

W. H. Muller, Holland

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 22, 30, 141, 157, 210, 320)

223. Stanitz, J. D., Approximate design method for high-solidity blade elements in compressors and turbines, *Nat. adv. Comm. Aero. tech. Note* 2408, 76 pp., July 1951.

This is an approximate design method for high-solidity cascades

for the determination of blade element profiles in compressible or incompressible flow, satisfying prescribed velocity distributions on the surfaces. The first approximation is one-dimensional in character and furnishes readily the required solidity and distributions of channel width and flow direction. In a second approximation desirable for solidities below 2, parabolic velocity variations are assumed across the channel. The method is valid for moderate radii of profile curvature compared to the channel width and excludes, therefore, leading and trailing edge regions. Two numerical examples are also presented.

Andrew Fejer, USA

224. **Bogdonoff, S. M., The performance of axial-flow compressors as affected by single-stage characteristics,** *J. aero. Sci.* 18, 5, 319–328, May 1951.

Paper contains the results of calculations of the off-design point behavior of three compressors, each designed for the same pressure ratio (3.2), mass flow, mean blade speed (648 ft/sec), and axial velocity (450 ft/sec). A symmetrical vector diagram was used and compressors of 6, 8, and 13 stages were obtained by altering the change in tangential velocity across a blade row and, hence, the air inlet and outlet angles. The analysis was simplified by neglecting three-dimensional and stage-interference effects, although blade-performance data and efficiency were obtained from cascades and single-stage test data. At design rpm the 6-stage compressor has the widest range of mass flow but the smallest range of pressure ratio. Two other assumptions for the variation in efficiency with mass flow in the single-stage were tried and showed marked effects, particularly in altering the location of the stage which stalls first.

William R. Hawthorne, England

225. **Simonin, R.-F., Operation of the water jet ejector** (in French), *C. R. Acad. Sci. Paris* **233,** 6, 465–466, Aug. 1951.

Précis of an analysis on the pumping rate of a water-jet type vacuum pump. Work is based on considerations of bubble formation and work against surface tension, but story is too brief for reviewer to follow details.

Stanley Corrsin, USA

226. **Johannesen, N. H., Ejector theory and experiments,** *Trans. Dan. Acad. tech. Sci. A. T. S.* no. 1, 176 pp., 1951.

This comprehensive survey contains an especially valuable bibliography of 185 references on ejector papers and 140 additional references on papers on allied subjects. Carefully documented discussions of the nozzle, jet, entrainment, and diffuser processes are given; however, little attention is given to the theory for a complete ejector. Experimental work on a single-stage, high-vacuum steam ejector is described, and the results of many tests are presented in graphical and tabular form.

H. G. Elrod, Jr., USA

227. **Otto, E. W., and Taylor, B. L., III, Dynamics of a turbojet engine considered as a quasi-static system,** *Nat. adv. Comm. Aero. Rep.* 1011, 12 pp., 1951.

The behavior of a typical jet engine during transient conditions is treated. An analysis of the transients is made, based on steady-state component data. The results are presented as a linear differential equation of engine acceleration as a function of fuel flow and engine speed. The coefficients of this equation, determined by analysis from steady-state performance characteristics and actual test data taken during transient conditions of operation, were found to check very well. The solution can be applied directly to control problems. The equation can be written in terms of corrected quantities, altitude corrections being made according to standard practice. Various methods of graphing the results for use in control applications are presented. Reviewer considers article to be a definite contribution toward reducing highly complex control problems to a more rational basis.

E. G. Allen, USA

✎228. **Durham, F. P., Aircraft jet powerplants,** New York Prentice-Hall, Inc., June 1951, xi + 326 pp. $5.

Book is written primarily as an undergraduate text for courses in aircraft jet engines. The effective treatment of the numerous topics covered makes the book valuable also to graduate students and engineers in this field.

The first 3 chapters review the parts of thermodynamics and fluid mechanics that are useful in subsequent discussion. Chapters 4 and 5 are devoted to cycle analysis and performance of turbojet engines. Chapter 6 gives similar analysis on turbopropeller engines. Chapters 7 to 11 treat the different components of a jet engine. There is one chapter on each of the following: duct and diffuser, compressor, burner, jet nozzle, and turbine. Chapters 12 and 13 discuss two special kinds of jet engines, namely, the ramjet and the rocket.

The theoretical aspect is held to such a level that students with previous courses in elementary thermodynamics and fluid mechanics should experience no difficulty. The flow analysis is, in general, limited to one-dimensional. Two topics on compressible flows are treated in some detail, namely, the constant-area flow with friction and heat addition, and shock waves.

Many important design features are discussed. Illustrations showing contemporary practice are considered an attractive feature of this book.

Hsuan Yeh, USA

Flow and Flight Test Techniques

(See also Revs. 11, 109, 174, 183, 249, 256, 266, 312)

229. **Harrop, R., A method for designing wind-tunnel contractions,** *J. roy. aero. Soc.* **55,** 483, 169–180, Mar. 1951.

Incompressible flow theory is used to calculate an axisymmetric contraction cone with favorable pressure gradients. The method consists of calculating the streamlines of a flow consisting of two equal vortex rings, placed symmetrically about the throat, combined with a uniform flow parallel to the axis. The strength of the vortexes determines the contraction ratio, and the length of the cone is fixed by the particular streamline chosen. Velocity distributions are plotted for contraction ratios of 9 to 1, 16 to 1, 25 to 1, and 38 to 1. The theoretical results obtained for a circular cross-section contraction are compared to experimental results obtained on a model of a proposed supersonic tunnel of rectangular cross section. This comparison shows that no adverse pressure gradients exist in the rectangular contraction section.

H. P. Liepman, USA

230. **Stack, J., Experimental methods for transonic research,** 3rd Anglo-Amer. aero. Conf., Brighton, Sept. 4–7, 1951, *Roy. aero. Soc.*, 563–592, 1951.

This survey of applied research (in the United States) in the transonic range is divided into sections dealing with: (1) Freely falling body; (2) rocket-propelled body; (3) wing-flow and "transonic-bump"; (4) whirling-arm technique; (5) wind tunnels, including axially symmetric nozzle, open and half-open throats; (6) full-scale flight research. Emphasis is on the comparison of results obtained by different methods. Experimental data cited are usually for NACA airfoil shapes, mainly pressure distributions. Some reference is made to problems of control, oscillations, etc. There is a somewhat detailed discussion of results with an axially symmetric nozzle and the focusing effect.

Discussion of the various methods is necessarily brief; it is a

concise summary of present applied research (in the United States). The number of references (five) seems small for a survey of this nature; this lack may be due to restrictions.

Anatol Roshko, USA

231. Schwarz, H., Methods and instruments for measuring smallest gas pressures (in German), *Arch. tech. Messen* **188,** T96–T97, Sept. 1951.

Paper discusses in form of a critical review most of the methods already known for measuring pressures from 1 to 10^{-1} Torr (1 Torr = 1 mm Hg). For those especially interested in this subject, paper can be a very useful guide, especially the 81 references.

S. F. Erdmann, Sweden

232. Kinsler, M. R., Influence of refraction on the applicability of the Zehnder-Mach interferometer to studies of cooled boundary layers, *Nat. adv. Comm. Aero. tech. Note* 2462, 39 pp., Sept. 1951.

Report presents a method for estimating effects of light refraction when evaluating interferograms of two-dimensional laminar and turbulent cooled boundary layers.

Equations for light-ray trajectories are developed, with certain assumptions, and results are presented graphically. It is shown that the effects of refraction become more pronounced as the wall-to-stream temperature ratio decreases.

The effects of reflection and diffraction at the model surface are discussed. Since the light rays are bent into the surface of the model which has a cooled boundary layer, the interferogram achieves only limited use in determining local heat-transfer coefficients at low temperature ratios. However, it should be very helpful for correcting boundary-layer profiles obtained with a Zehnder-Mach interferometer.

Suggestions for building a typical model test-section configuration are given and a numerical example is calculated.

Report should prove useful to researchers working on cooled boundary-layer problems with Zehnder-Mach interferometers in wind tunnels and shock tubes. Irvine I. Glass, Canada

233. Bennett, F. D., Effect of size and spectral purity of source on fringe pattern of the Mach-Zehnder interferometer, *J. appl. Phys.* **22,** 6, 776–779, June 1951.

The distribution of light intensity in the undisturbed fringe pattern of a Mach-Zehnder interferometer is estimated under the assumption of a circular light source normal to the axis, whose spectrum has Gaussian intensity distribution. Investigation shows that in all practically useful cases the finite size of the source and its polychromaticity reduce the fringe contrast below experimental detectability at fringe numbers much smaller than those at which the induced deviation of fringe width from its ideal value for a monochromatic point source becomes observable.

F. J. Weyl, USA

234. Kliner, W. J., and Wilson, J. H., Spin-tunnel investigation of the effects of mass and dimensional variations on the spinning characteristics of a low-wing single-vertical-tail model typical of personal-owner airplanes, *Nat. adv. Comm. Aero. tech. Note* 2352, 130 pp., May 1951.

Paper deals with the effects of tail-damping power factor, mass distribution, rearward movement of the center of gravity, tail size, and arrangement and wing shape on the spin and recovery characteristics of a typical four-place private-type airplane model.

Tests were performed in the Langley 20-ft free-spinning tunnel. With controls positioned, the model was launched by hand with rotation into the vertically rising air stream. After a number of turns in the established spin, a recovery attempt was made by moving the controls by a remote-control mechanism and the spin data obtained were then converted to corresponding full-scale values. Various techniques for spin recovery were studied.

Results indicate satisfactory recovery characteristics even for small tail-damping power factor using a full rapid rudder reversal followed by forward movement of the stick ½ turn later. Mass changes had appreciable effect on the spin recovery for low damping power factor but small effect for high damping factor. Changing the vertical or horizontal tail design had small effect on spin recovery, except for a loading condition having the mass extended along the fuselage and retracted along the wings combined with low damping power factor. Wing planform variation had negligible effect on spin recovery.

The data presented are quite extensive and reviewer believes very useful in the design of personal-type aircraft.

Ray E. Bolz, USA

235. Mattioli, E., Electrical measurements of turbulence (in Italian), *Aerotecnica* **31, 3,** 169–183, June 1951.

A survey of methods adopted to measure turbulent velocity fluctuations by the hot-wire anemometer and glow discharge anemometer. Reviewer believes that certain important developments of the past fifteen years should have been included in so extensive a survey; e.g., the "X-meter" for transversal velocity and shear measurement, the measurement of temperature fluctuations, square-wave thermal lag calibration, constant-temperature feedback system, correction for finite wire length.

Leslie S. G. Kovasznay, USA

236. Buchan, A. L., Harris, K. D., and Somervail, P. M., The measurement of the derivative z_w for an oscillating aerofoil, *Aero. Res. Counc. Lond. curr. Pap.* 52, 23 pp., 9 figs., 1951.

See AMR 4, Rev. 2224.

Thermodynamics

(See also Revs. 122, 168, 252, 256, 260)

237. Pischinger, A., Technical thermodynamics. Introduction to principles and application [Technische Thermodynamik. Einführung in Grundlagen und Anwendung], Wien, Springer-Verlag, 1951, viii + 231 pp., 179 figs., 7 tables. $4; bound, $4.75.

This volume constitutes an introductory course for mechanical engineering students. The clearly written text deals briefly with the subjects commonly presented in such a course, such as the First and Second Laws of thermodynamics, perfect gas laws, properties of real gases and vapors, combustion, flow through channels and nozzles, and applications of thermodynamic principles to the analysis of heat power engines and cycles and refrigeration cycles. The study of some of the applications is limited to a discussion of their entropy diagrams without actual analysis in terms of thermodynamic equations. Eric F. Lype, USA

238. Zemansky, M. W., Heat and thermodynamics, 3rd ed., New York, Toronto, London; McGraw-Hill Book Co., Inc., Sept. 1951, 456 pp. $6.

The approach and organization of the previous editions of this excellent book are retained in the present edition. The fundamentals of the subject are developed in the first ten chapters, and applications of interest to the student of physics, of physical chemistry, and of engineering are presented in the last nine chapters. Much of the material from the previous edition has been retained unchanged, although parts have been rewritten or ex-

panded to make them clearer, more rigorous, or to bring them up to date. In addition, considerable new material has been added.

In the first ten chapters the principal change consists in the addition of a chapter on the transfer of heat. Material on natural convection which appeared in the previous edition has been expanded, and new material on forced convection and single-current heat exchangers has been added. Changes in the last nine chapters are more extensive and include the introduction of a new treatment of the thermocouple, a treatment of dielectrics and piezoelectricity, and a separate chapter on the physics of very low temperatures. Some of the material in this new chapter appeared in the previous edition but much of it is new.

The student will find a number of interesting and unusual features. For example, the exposition of the first law is that of Caratheodory. The author first introduces the concept of an adiabatic wall and then states the First Law in the form, "If a system is caused to change from an initial state to a final state by adiabatic means only, the work done is the same for all adiabatic paths connecting the two states." The concept of an internal-energy function follows directly from this statement, and heat is then defined in terms of work and internal energy.

Another interesting feature is that, in his illustrations, the author treats not only the gaseous and liquid systems usually considered in thermodynamics but also systems such as stretched wires, surface films, reversible cells, and paramagnetic solids. In his discussion of the Carnot cycle, for example, he describes the cycle for a real gas, a mixture of liquid and vapor, a reversible electric cell, and a paramagnetic substance.

Still another departure from the usual treatment is the introduction early in the book of what is called a "quasistatic process." A system is said to undergo such a process if the system is at all times infinitesimally near a state of equilibrium. Later, after he has discussed the second law and the concept of a reversible process, the author shows the relation between quasistatic and reversible processes. This approach should be particularly helpful to the student studying thermodynamics for the first time.

In reviewer's opinion this book, although of interest principally to the physicist, is one which should be a part of the personal library of every advanced student of engineering.

H. J. Stoever, USA

239. Gol'denberg, S. A., Investigation of the process of turbulent combustion taking into account secondary reactions (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 5, 657–666, May 1951.

Results of turbulent combustion in a carbon tube with considerations of secondary reactions are given for combustion of CO_2 and combustion of CO. Experiments were made to determine the character of combustion in various sections of the tube. It was found that under the test conditions, as under the laminar flow conditions, combustion of CO takes place in a diffusion manner and in the proximity of the tube wall. The value of the gas-exchange coefficient has been determined for the temperature range of 500–1000 C.

L. M. Tichvinsky, USA

240. De Groot, S. R., Thermodynamics of irreversible processes, New York, Interscience Publishers, Inc.; Amsterdam, North Holland Publishing Co., 1951, xvi + 242 pp. $5.

The first systematic, general treatment in English of a macroscopic theory of irreversible thermodynamics based upon Onsager's theory [*Phys. Rev.* **37,** p. 405, 1931; **38,** p. 2265, 1931]. Chapter I surveys various theories of irreversible phenomena and concludes that a satisfactory theory can be based upon four postulates: (A) The rate of entropy production $\sigma = \Sigma_i J_i X_i$ is positive definite. (B) The entropy balance and hence σ is calculated from the Gibbs relation $Tds = du + Pdv - \Sigma_k \mu_k dc_k$ where s, u, and v are specific entropy, energy, and volume, P the pressure, T the temperature, μ_k the chemical potential, and c_k the concentration of component k. (C) The phenomenological laws $J_i = \Sigma_k L_{ik} X_k$ linearly relate the fluxes J_i and the forces X_i and exhibit the cross phenomena arising from mutual interference between two or more irreversible effects. (D) The Onsager reciprocal relations $L_{ik} = L_{ki}$.

Starting from (B) one identifies the forces X_i (temperature gradient, pressure gradient, etc.) and the fluxes J_i (heat flow, mass flow, etc.) and then determines the physical meaning of the L_{ik} defined by (C) and (D). The choice of X_i and J_i is not unique, but the reciprocal relations (D) remain invariant under any linear transformation of the fluxes and forces. All this is clearly shown by the author in the general case and is illustrated by numerous special examples. Chapter II derives the Onsager relations, themselves macroscopic in nature, from the principle of microscopic reversibility. Chapters III–IX apply the theory to special phenomena such as diffusion of matter, flow of heat in simple substances, effect of chemical reactions or electric charges upon these flows in discontinuous and continuous systems, and finally, the classically famous phenomena of thermo-electricity which historically were the first irreversible effects to receive careful study. The power and beauty of the theory are apparent throughout. Chapter X is also devoted to general theory and includes a consideration of the various stationary states, defined as states of minimum entropy production when some of the forces are constant. Chapter XI concludes the book with further discussion of the foundations, hypotheses, and limitations of the theory.

Bridgman [*Rev mod. Phys.* **22,** 52–63, 1950] has criticized assumption (B) as being essentially reversible, and consequently the theory of this book does not apply to all irreversible phenomena. That may be, but the theory presented does apply to a large number of phenomena not covered by classical thermodynamics, and the author is careful to point out its limited validity. Continuous flow processes, with or without burning, would appear to fall within the compass of the theory. Weak shock-wave phenomena could be included, if deviation from equilibrium is not too large. Such phenomena are not specifically included in the book. These and other applications will be found in papers listed in a fairly complete bibliography. One notable omission is the paper of Curtiss and Hirschfelder [AMR **4,** Rev. 405] which may have appeared too late for inclusion. There are many annoying misprints throughout the book, but the careful reader will find them.

The book is a stimulating survey of some recent work on the thermodynamics of nonequilibrium processes. It is a physicist's treatment and assumes considerable more knowledge of classical thermodynamics than many engineers will have. To those who have the necessary background it should serve as an introduction to Onsager's theory which deserves a wider dissemination.

Robert E. Street, USA

241. Haase, R., Contribution to the thermodynamics of irreversible processes. I (in German), *Z. Naturforsch.* **6a,** 8, 420–437, Aug. 1951.

Irreversible processes involve approximately linear relations between "generalized forces" (e.g., chemical affinity, gradient of temperature) and "fluxes" (e.g., rate of reaction, flow of heat); they are specified in terms of the empirical constants appearing in these relations. By a systematic generalization of thermodynamics [see S. R. De Groot, preceding review], relations between the above constants can be established. Author discusses the conditions for the validity of this theory and points out that there is considerable latitude in defining forces and fluxes. Because of

this he reformulates the theory in terms of the "reduced flow of heat" as obtained by deducting the heat associated with convection and diffusion of matter from the total heat that is transported. He shows that in this formulation new and particularly simple and intuitive relations hold between the constants appearing in the equations of the theory. R. Eisenschitz, England

Heat and Mass Transfer

(See also Revs. 50, 192, 196)

242. Gunther, F. C., Photographic study of surface-boiling heat transfer to water with forced convection, *Trans. Amer. Soc. mech. Engrs.* **73,** 2, 115–123, Feb. 1951.

Tests have been performed in which the boiling of water on a metal strip was investigated photographically over a range of subcooling, liquid velocity, and heat flux rates. Detailed studies of the photographs resulted in data concerning rate of growth and collapse of bubbles, bubble size, population, and appearance rate.
Jackson R. Stalder, USA

General Discussion on Heat Transfer, London Conference

The following material was contributed to the Conference held in London, Sept. 11–13, 1951. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs.:

243. Friedman, S. J., and Mueller, A. C., Heat transfer to flat surfaces, Sect. II, 5 pp.

Heat-transfer measurements were made between air and a horizontal heated plate where the air impinged vertically upon the plate from a multitude of holes, slots, or nozzles.

The best type of air flow is from perforated plates which have a free area of 2 to 3% and are spaced about 4 to 6-holes diameters from the sheets. Some nonuniformity of heat transfer across a sheet is indicated, although it is small (around 10% on the average). Localized areas immediately under a jet may show larger deviations. From authors' summary

244. Anthony, M. L., Temperature distributions in slabs with a linear temperature rise at one surface. I, II, Sect. III, 12 pp.

The temperature distribution and the heat flux are found analytically for the case of one-dimensional heat conduction in a single finite slab in which one boundary has a linear temperature rise, while the other boundary is either insulated, transfers heat by convection into a medium of zero temperature, or is kept at zero temperature. Dimensionless numerical results show the temperature and the heat flux as functions of the parameters involved. In part II, the analysis is extended to the case of a two-slab body whose external faces are subject to the same temperature conditions which were considered in part I. As a practical application of the analysis, the temperature and heat flux are given for a composite slab of polyvinyl butyral plastic and plate glass which, in the first calculation, is assumed to be made of slabs of equal thickness and in the second case to have an infinitely thick slab of plate glass. The results are shown for several values of the dimensionless surface coefficient of heat transfer.
From author's summary by Ione D. V. Faro, USA

245. Seban, R. A., and Shimazaki, T. T., Temperature distributions for air flowing turbulently in a smooth heated pipe, Sect. II, 5 pp.

The temperature distribution in a stream of air flowing turbulently in a heated vertical pipe has been measured for flows with Reynolds numbers between 5400 and 54,000. These measurements have been made sufficiently close to the wall to define conditions in the flow sublayers. Velocity distribution measurements have been made in conjunction with the temperature measurements to define the turbulent character of the flow. Comparison of these measurements with temperature distributions predicted from the Kármán analogy theory reveals excellent agreement immediately adjacent to the wall, with some discrepancies in the outer portion of the "buffer" region. It appears that agreement in the turbulent region would be improved by taking a ratio of diffusivities greater than unity over part of the region.
From authors' summary

246. Schlinger, W. G., Berry, V. J., Mason, J. L., and Sage, B. H., Prediction of temperature gradients in turbulent streams, Sect. II, 4 pp.

Paper discusses heat transfer between parallel walls and fluid flowing between, considering temperature profiles normal to flow direction. Computations were performed by analog computer. Comparison of results with one-dimensional temperature variation of McAdams should have been extended to temperature profiles. David C. Prince, Jr., USA

247. Carpenter, F. G., and Colburn, A. P., The effect of vapor velocity on condensation inside tubes, Sect. I, 7 pp.

Pure vapors of steam, methanol, ethanol, toluene, and trichlorethylene were condensed inside a vertical tube 0.459-in. ID and 8 ft long, with inlet velocities up to 500 ft/sec. Temperatures of the cooling water were measured by thermocouples located in the jacket at 6-in. intervals. The vapor temperature was measured at any point along the tube axis by a traveling thermocouple. The data were calculated as average coefficients of heat transfer for the entire tube, and also as local values at various points along the tube.

Much greater heat-transfer coefficients are obtained when vapors condense in the presence of high vapor velocities than when the velocity is negligible.

The flow of the condensate layer tends to be essentially laminar in the absence of vapor velocity up to Reynolds numbers of 2000; in the presence of high vapor friction the layer becomes turbulent at Reynolds numbers around 240.

For a correct design of a condenser with vapors inside tubes, three regions should be considered. For the short upper region, the condensate flow is entirely laminar but vapor friction is large; for the second regions for $4\Gamma/\mu$ greater than 250, a turbulent condensate should be employed; while for the lowest region no vapor friction is involved either in turbulent or laminar flow.

An approximate design relation for vapor condensing inside a tube is one which is based on the condensate properties and the mass flow of the vapors. Byron E. Short, USA

248. Donaldson, J., and Watson, W. W., Effect of turbulence in thermal diffusion columns, *Phys. Rev.* **82,** 6, 909–913, June 1951.

Paper presents experimental results of investigation of effect of turbulence on the separation factor and transport in a thermal diffusion isotope separation column. Data are presented on argon gas which indicate a marked increase in separation factor with turbulence for the columns tested.

Authors point out that a complete explanation of the phenomena is not known and that further experimental and theoreti-

cal work is necessary to maximize the separation effect of turbulence. William A. Wolfe, Canada

249. **Boelter, L. M. K., Sanders, V. D., Young, G., Morgan, M., and Morrin, E. H., An investigation of aircraft heaters. XXXIV. Experimental determination of thermal and hydrodynamical behavior of air flowing between a flat and a wave-shaped plate,** *Nat. adv. Comm. Aero. tech. Note* 2426, 30 pp., Aug. 1951.

Turbulence caused by air flowing between a heated flat surface and a wavy unheated surface increases as much as twofold the heat transferred from the flat plate for narrow duct spacings over that for flow between two flat plates. This phenomenon does not occur, however, at wide duct widths. The values of the local unit thermal conductance near the leading edge of the heated plate when the wave-shaped plate is placed upstream of the heated plate are higher than those for the case where the plates are placed in exact opposition because of the generated turbulence of the air. The static-pressure drop for flow along the wave-shaped plate is 4 to 10 times (depending on the duct width and shape of plate) that for flow along straight ducts. From authors' summary

250. **Boelter, L. M. K., Elswick, W. R., Sanders, V. D., and Rubesin, M. W., An investigation of aircraft heaters. XXXVI. Preliminary investigation of a combustion-type aircraft heater,** *Nat. adv. Comm. Aero. tech. Note* 2428, 15 pp., Aug. 1951.

From an experimental investigation of an aircraft combustion-type heater, the following conclusions were drawn: (1) The effect of added heat transfer from the combustion gases due to radiation from the solid or gaseous constituents of the gases to the combustion chamber walls is negligible. (2) The effect of added heat transfer from the combustion gases due to the increase in the effective thermal conductance within the combustion of fuel is negligible. From authors' summary

251. **Plunkett, R., A method for the calculation of heat transfer in solids with temperature-dependent properties,** *Trans. Amer. Soc. mech. Engrs.* **73,** 5, 605–607, July 1951.

Paper deals with two ideas: (1) Linearization of the space-dependent derivatives of the heat-transfer equation according to the suggestion of Kirchhoff, whereby the temperature-dependent properties appear only in the coefficient of the time derivative; this procedure makes the differential equation more amenable to numerical integration techniques; (2) the order of the error involved in different finite-difference approximations to the partial derivatives.

Method is illustrated by application to a problem previously solved by Dusinberre in a different way, viz., heat flow through a brick furnace wall.

Paper is followed by important discussion with G. M. Dusinberre and D. H. Fax. L. Jansen, Switzerland

252. **Chukhanov, Z. F., Equation of motion of a burning region** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **77,** 4, 611–614, Apr. 1951.

The problem considered is the behavior of the burning region within a cylindrical blast furnace filled with solid fuel lumps and supplied with an air current. Author calculates the speed of propagation of the burning region by considering the ratio of heat supplied to the adjacent fuel layer by radiation to the heat needed to raise the temperature of this layer up to the ignition point. Aerodynamical and heat-transfer problems underlying the phenomenon in question are not worked out. Perhaps such problems do not arise owing to the extremely low Reynolds number of the air current (less than 10; reference length, though, not mentioned). A. von Baranoff, France

253. **Holms, A. G., A biharmonic relaxation method for calculating thermal stress in cooled irregular cylinders,** *Nat. adv. Comm. Aero. tech. Note* 2434, 49 pp., Aug. 1951.

A numerical procedure based on finite differences is developed for determining steady-state thermal stresses in irregular cylinders with one or more internal boundaries. The requirements of force-free boundaries and single-valued displacements are formulated in terms of operations on the Airy stress function. The operations, as well as the relation of the function to the thermal equations, are expressed in finite difference form. In illustrative example, relaxation techniques are used and recommended. The examples are of cases for which valuations are known. Comparisons indicate the results to be good approximations of the correct values. Gerald Pickett, USA

254. **Jacq, J., Contribution to the graphic study of variable thermic systems** (in French), *C. R. Acad. Sci. Paris* **232,** 25, 2292–2295, June 1951.

Author completes his previous article [AMR **4,** Rev. 3392] by applying his method to the case where there are two different types of walls as well as other material present in the region considered.

From author's summary by L. Jansen, Switzerland

255. **Charnfi, I. A., On methods of linearization of nonlinear equations of the type of heat-conduction equations** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 829–838, June 1951.

Paper treats, in far too much detail and with unnecessary complications, solution of simultaneous differential equations of the type $\vec{a} = f(b)\ \text{grad}\ b$, $\partial b/\partial t = K\ \text{div}\ \vec{a}$ (K = constant). Either one assumes that $f(b)$ varies so little that it can be treated as constant, or one assumes that both $d\ln f/db$ and df/db are essentially constant in the region of interest. In both cases the solution reduces to the solution of an equation of the type $\partial c/\partial t + \kappa\nabla^2 c = 0$ (κ = constant). Examples discussed are heat conduction, filtering of gases through porous media, and filtering of fluids. D. ter Haar, Scotland

256. **Pierre, B., Influence of frames on insulation of cold storage chambers on board ships,** *Trans. roy. Inst. Technol. Stockholm* no. 50, 64 pp., 1951.

The analogy between electric and thermal potential fields is discussed briefly and a simple method presented for the study of steady-state thermal conduction systems of complex geometric configuration. Experimental data obtained on models of various wall constructions of cold storage chambers on board ship are presented. Walls containing I, T, and U channel forms of varying relative dimensions are tested and the influence of these sections on the insulating value of cold storage chamber walls and the temperature distribution within the insulation of such walls are studied. The data are reported as charts having dimensionless parameters representing ratios of physical dimensions of wall and frame sections, temperatures, and thermal resistances of the wall with and without the presence of frames. Analytical relations are presented and illustrative examples are given for calculating the influence of frames on insulating walls and the most economical thickness of insulation. Y. S. Touloukian, USA

257. **Grenier, C., Thermal conductivity of liquid helium. I,** *Phys. Rev.* (2), **83,** 3, 598–603, Aug. 1951.

Direct measurements have been made of the thermal conductivity of liquid helium over the temperature range from its normal boiling point at 4.2 K to a temperature within a few hundredths of a degree of the λ-point. The results show that the

thermal conductivity decreases linearly with temperature from a value of 6.5×10^{-5} cal/deg cm sec at 4.2 K to about 4.5×10^{-5} cal/deg cm sec close to the λ-point. No large deviation from linearity can be detected in the heat conductivity until about 0.2 degree from the transition temperature of 2.18 K.

From author's summary

258. Sharma, S. S., Thermal expansion of crystals. Part VII. Barite, *Proc. Indian Acad. Sci. Sec. A*, **33,** 5, 283–289, May 1951.

Results are summarized in tables giving coefficients of linear expansion parallel to the *a*-, *b*-, and *c*-axis, in a direction equally inclined to the axes, and perpendicular to *m*-face. Ed.

259. Klemens, P. G., The thermal conductivity of dielectric solids at low temperatures, *Proc. roy. Soc. Lond. Ser. A*, **208,** 1092, 108–133, Aug. 1951.

A general formula for the thermal conductivity of dielectric solids was obtained for the temperature range below 100 K. It was in good agreement with observed values for quartz glass and in fair agreement with quartz, potassium chloride, and potassium bromide crystals. This investigation of statistical equilibrium permits predictions of the effects of neutron-induced defects in a crystal lattice. W. L. Sibbitt, USA

260. Koçak, H., Development of a heat-transfer probe for internal combustion engines (in German), *Mitt. Inst. Thermodyn. Verbrennungsmotor. ETH, Zurich* no. 9, 59 pp., 1950.

Paper deals with design, construction, and use of heat-transfer probe to measure cyclic-average over-all heat-transfer coefficients from cylinder gas to probe and, simultaneously, cyclic-average gas temperatures near top of cylinder. One-dimensional heat flow is assumed and radiation is neglected. Very detailed description is given to development of probe. However, only a few test results are given. Over-all heat-transfer coefficients and corresponding gas temperatures were plotted vs. indicated mean effective pressure and mean piston speed. Author suggests over-all heat-transfer coefficients proportional to cubic root of mean piston speed.

Reviewer believes that this probe will serve as a useful tool in research. However, due to complexity of problem and simplifying assumptions used, test results obtained are, at best, qualitative.

T. Y. Toong, USA

261. London, A. L., and Kays, W. M., The liquid-coupled indirect transfer regenerator for gas-turbine plants, *Trans. Amer. Soc. mech. Engrs.* **73,** 5, 529–540, July 1951.

Four design studies of gas-turbine plants employing liquid-coupled indirect-transfer regenerator are given. This regenerator has many advantages; however, a suitable coupling liquid is required. M. J. Goglia, USA

Acoustics

262. Hartmann, J., and Trudsø, E., Synchronisation of air-jet generators with an appendix on the stem generator, *K. Danske Vidensk. Selsk. Mat. Fys. Medd.* **26,** 10, 39 pp., 1951. $1.

Particularly for smoke precipitation, homogeneous acoustic fields of high frequency and large intensity and extension are desirable. As the power of a Hartmann generator, though 6 watts at 50 keps, is limited, experiments were made, first, to increase the radiating circumference of the resonator, and second, to find the conditions for synchronization of two generators. The variation of the frequency and oscillograms of the wave form are given.

In the "stem-generator" the resonator is coupled to the nozzle by a coaxial rod. It operates at lower pressure than the ordinary Hartmann generator, and deviates also in other respects. In the synchronization experiments it did not compete too well with the older type, but construction is simpler, and the space occupied is reduced. R. Vermeulen, Holland

263. De Schwarz, M. J., On some analytical questions concerning the calculation of the acoustic absorption coefficient of cylinders lined with glass felt (in Italian), *Cons. Naz. Ricer.* no. 299 = *Atti Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. Nat.* (8) **10,** 2, 152–155, Feb. 1951.

Author gives details of calculation of absorption coefficient by method of Cook and Chrzanowski [*J. acoust. Soc. Amer.* **4,** p. 318, 1946]. Results are obtained by direct summation of a series of Bessel functions. Author estimates error made by terminating the series at the *m*th term. Though this appears to be a rather crude approximation, the method can probably be used for other slowly converging series. J. M. Jackson, Scotland

264. Grossetti, E., On the distribution of intensity of the ultrasonic field in liquids (in Italian), *Nuovo Cim.* **8,** 5, 301–306, May 1951.

Ultrasonic waves, produced by a plane source the diameter of which is essentially larger than their wave length, progress similar to light waves. Paper deals with tests which shall prove that ultrasonic sound beams of that kind sometimes show diffusion analogous to the diffusion of light. Theoretical studies of some authors indicate this possibility. Tests are conducted with quartz plate producing 1.8 M cps in various liquids. Intensity of ultrasonic field was determined optically by application of theory of Raman. Though evaluation of tests is difficult, satisfactory results were obtained. In colloidal solutions of Ag and S, the beam shows no spreading, though colloidal particles are of the order of magnitude which is necessary, theoretically, for diffusion. Definite spreading of the ultrasonic waves was obtained with mixtures of water and liquids of higher viscosity (glycerin, solutions of carmelized sugar).

Author concludes that results actually must be explained as the effect of ultrasonic diffusion. For a definite proof more tests must be conducted with other liquids and other wave lengths.

Heinrich J. Ramm, USA

265. Beranek, L. L., Marshall, J. L., Cudworth, A. L., and Peterson, A. P. G., Calculation and measurement of the loudness of sound, *J. acoust. Soc. Amer.* **23,** 3, 261–269, May 1951.

An equivalent-tone method is described for calculating the loudness of continuous spectrum noise. The noise spectrum is divided into bands of frequencies, and the sound-pressure level in decibels is determined for each band. From experimental data given, it appears that equal-loudness curves for bands of noise should closely resemble those already established for pure tones. Hence, using the mean frequency of each noise band, the loudness level in phons is found corresponding to the sound-pressure level. Use of the Fletcher-Munson curve for loudness vs. loudness level then gives the loudness in sones. Finally, the individual values contributed by each band are added to find the total value in sones. The method is simple enough to provide the basis for a practical loudness meter. Agreement between calculated and experimental value is good.

Paper does not mention that one of the authors has developed an octave-band noise analyzer, which is commercially available. This new portable instrument satisfies the demand for an analyzer with fewer bands, and accomplishes the first step in the equivalent-tone method. It should be noted, however, that such an instru-

ment does not necessarily lend itself to the accurate analysis of sound composed of a fundamental frequency and its harmonics, as is the case in transformer noise. E. G. Fischer, USA

266. **Donaldson, C. duP., and Jones, J. J., Some measurements of the effect of gaseous imperfections on the critical pressure ratio in air and the speed of sound in nitrogen,** *Nat. adv. Comm. Aero. tech. Note* 2437, 15 pp., Aug. 1951.

Experiments were made to measure the speed of sound in nitrogen at room temperatures in the pressure range of 0 to 2000 psi, and the critical pressure ratio of air expanded insentropically from stagnation conditions in the same range. Experimental results were then compared with values obtained by using the van der Waals equation and the Beattie-Bridgeman equation.

The speed of sound, as measured, agreed within 1.5% of that predicted by the Beattie-Bridgeman equation and within 4% of that predicted by the van der Waals equation over the entire test range. The measured critical pressure ratio agreed with that predicted by the Beattie-Bridgeman equation within the experimental accuracy of the tests and with that predicted by the van der Waals equation within 1%. From authors' summary

267. **Twersky, V., On the nonspecular reflection of sound from planes with absorbent bosses,** *J. acoust. Soc. Amer.* **23,** 3, 336–338, May 1951.

Author extends his previous theoretical investigations on the nonspecular reflection from planes with bosses of ∞ impedance [title source, **22,** 5, 539–546, Sept. 1950] to those from planes of ∞ or 0 impedance with semicylindrical, cylindrical, semispherical, and spherical bosses of arbitrary impedance. By method of image, he gives equations describing the space distribution of the wave field and finds that, in comparison to bosses of ∞ impedance, the total radiation reflected by a plane with a single boss at the specular angle is increased if the real part of its impedance is smaller than its imaginary part, and vice versa. For small finite distribution of bosses, their finite impedance shifts the critical value of the angle of incidence for which the reflection at the specular angle consists only of the specular component, while for infinite uniform random distributions the effect of bosses consists essentially in changing the impedance of the plane.

Jaroslav Pachner, Czechoslovakia

268. **Rzhevkin, S. N., Visualization of acoustic waves modulated in space** (in Russian), *Usp. fiz. Nauk* **64,** 1, 70–79, May 1951.

When sound is passed through a grid or a screen and down a tube, the effective source is spatially modulated. This paper analyzes such waves by resolving them into elementary waves, following the usual methods of wave-guide analysis and diffraction theory. Calculations are presented for effective wave lengths and intensity patterns. The sound waves can be made visible by the use of a schlieren technique. Such photographs can be taken even without a stroboscopic light source, since there will be certain points which always (or never) possess vibrations (pseudo-standing waves). Several excellent photographs of these patterns are reproduced. R. T. Beyer, USA

269. **Fukuda, E., Vibrational study of the wood used for the sound boards of pianos,** *Nature* **166,** 4227, 772–773, Nov. 1950.

270. **Ramachandra Rao, B., Ultrasonic velocities in liquids by a new method,** *Proc. Indian Acad. Sci. Sec. A,* **34,** 1, 24–26, July 1951.

A new method of determining velocities in transparent and opaque liquids, using ultrasonic frequencies, is described. Ultrasonic waves generated by a tourmaline wedge give a range of 3–7 mc/sec. Results obtained for a number of organic and inorganic liquids are given. They compare well with values reported earlier in the literature. Only 0.25 cc is required, hence the method is particularly suitable for liquids available in very small quantities.

From author's summary by W. H. Pielemeier, USA

271. **Lawhead, R. B., and Rudnick, I., Acoustic wave propagation along a constant normal impedance boundary,** *J. acoust. Soc. Amer.* **23,** 5, 546–549, Sept. 1951.

An expression is obtained for the amplitude and phase of an acoustic wave above a boundary due to a point source on or near a boundary which exhibits a constant normal specific acoustic impedance. This is shown to be a special case of the solution for an isotropic medium with constant characteristic acoustic impedance; specifically, the case is one in which the ratio of the propagation constant in the upper medium to that in the lower approaches 0.

A material which obeyed a constant normal impedance boundary condition was constructed from ordinary drinking straws. Measurements of amplitude and phase as a function of receiver position along and above the boundary showed good agreement with theory.

The nature of the approximations involved in the solution is discussed, and it is shown to be an adequate representation of the sound field for distances greater than one wave length from the source.

From authors' summary by Charles Newman, USA

272. **Noury, J., Study of the velocity of ultrasonics in fluids in the neighborhood of the critical point** (in French), *C. R. Acad. Sci. Paris* **233,** 7, 516–518, Aug. 1951.

One table and two curves for velocities in N_2O and CO_2.

273. **Faran, J. J., Jr., Sound scattering by solid cylinders and spheres,** *J. acoust. Soc. Amer.* **23,** 4, 405–418, July 1951.

A precise theoretical analysis is made which takes into account shear waves which exist when sound is scattered from solid cylinders and spheres in water. The results are put into numerical form and compared with experimental data. The experiment described uses a pulse source and a receiver and, by frequency modulation, means are available at the receiver to distinguish residual scattering (from the container) caused by previous pulses as distinguished from scattering of the most recent pulse. When appreciable interference is obtained, one changes the pulse-repetition rate. Both theoretically and experimentally, it is proved that rapid changes with frequency in the distribution-in-angle of the scattered sound and in the total scattered energy occur near frequencies of normal modes of free vibration of the scattered body. Keeve M. Siegel, USA

Ballistics, Detonics (Explosions)

(See also Rev. 146)

274. **Pennycuick, K., Effect of cross-wind on a projectile,** *Nature* **168,** 4262, p. 41, July 1951.

Integrating the equation of motion along the trajectory

$$m\ddot{x} = -\rho(v^2 + w^2)v^2 f_R$$

where m is mass of projectile (lb), x range along the trajectory (ft), ρ air density (lb/ft^3), r radius of projectile (ft), f_R drag coefficient, v muzzle velocity relative to the air (ft/sec), w velocity of cross-wind (ft/sec), author obtains for drift

$$z = 0.000067\ wvt^2d^2f_R/m\ \text{(ft)}.$$

Equation is valid at short times of flight only. Result is better at subsonic velocities than at supersonic velocities.

D. Mazkevich, USA

275. Garnier, M., Remarkable points on a trajectory (in French), *Mémor. Artill. fr.* **25,** 1, 9–76, 1951.

Chapter III of the present work [for Chapters I, II, see AMR **4,** Rev. 4009] contains exact explanations on the computation of curved trajectories of a shell and of the remarkable points. Detailed forms are given for the calculation: first, new amplified forms for the calculation of the trajectory (method G.H.M.); then auxiliary forms for the computation of derivations (for the expansion in series), which are used in the formulas for the calculation of remarkable points, such as the point of minimal velocity, etc. All forms are arranged for logarithmic calculations in such a manner that they are usable without special mathematical knowledge.

H. Schardin, Germany

276. Quihillalt, O. A., Motion of a projectile in the air (in French), *Mémor. Artill. fr.* **25,** 1, 223–250, 1951.

This translation of a report published in the *Argentine Boletin del Centro Naval* in 1940 gives a detailed account of the numerical integration of the equations that determine the yawing motion of the spinning shell using an analytico-geometric method due to Count Magnus de Sparre. Two cases are examined, viz., a six-inch shell fired with muzzle velocity 720 m/sec at angles 10° and 45°, respectively. The force (torque) function employed accounts for the usual normal force (overturning moment) but ignores Magnus effects entirely.

The results for the 10° trajectory show a wobbling of the shell toward what appears to be the yaw of repose, for which the plane of yaw lies at nearly 90° to the right of the vertical plane containing the trajectory. For the 45° trajectory the results are similar up to the summit save for the fact that, at the outset, the nose of the shell makes several small precessions about the trajectory. Beyond the summit the shell precesses like a top. The author concludes that the calculations support, in the main, several laws enunciated by Mayewsky.

Frederick D. Bennett, USA

277. Thomas, R. N., and Whipple, F. L., Astroballistic heat transfer, *J. aero. Sci.* **18,** 9, 636–637, Sept. 1951.

Some current work on heat transfer to rapidly moving objects is summarized. The work embodies free-flight study of ablation.

From authors' summary

278. Buchmann, E., The response of simple floating targets to under-bottom explosion attack, *David W. Taylor Mod. Basin Rep.* 749, 34 pp., June 1951.

Underwater explosion tests have been conducted against simple cube-shaped floating wooden blocks, 10 × 11 × 10 in. and 20 × 20 × 20 in. Charges were fired below the center of the blocks at distances from contact up to 10 ft. The charge weights varied from 1 gm to 90 gms.

The response of the targets was measured by recording the displacement, velocity, and, in some cases, the acceleration. High-speed motion pictures of the pulsation and migration of the gas bubble under water were taken simultaneously; these pictures also showed the occurrence of cavitation.

The response of the targets could be correlated with the different phenomena of the underwater explosions such as the shock wave, bubble pulses, cavitation, bubble expansion and contraction, and migration. The results are compared with theory and show that the response of the target resembles that of the water displaced by the target.

A few tests were made with a submerged target having the weight of the displaced water. The response also resembled that of the displaced water.

From author's summary by Angelo Miele, Argentina

Soil Mechanics, Seepage

(See also Revs. 40, 155, 164, 168)

279. Terracini, C., Filtration of water under a river dam founded on permeable soil (in Italian), *Atti Accad. Sci. Torino* **84,** 1, 139–148, 1949–1950.

Assumed are: Darcy-Ritter law and two-dimensional irrotational motion. Base of dam is assumed to be below soil level, and equal upstream and downstream cutoffs are provided. Solution is obtained by mapping system upon a half plane by Schwarz-Christoffel transformation and deducing from same the velocity-potential function.

Solution of problem involves a difficult determination of three constants. "Inverse" problem of designing structure to insure given amounts of flow and pressure drop allows a straightforward solution involving elliptic integrals and functions.

Giuseppe Evangelisti, USA

280. Shekhtman, Yu. M., On the determination of the volume concentration in filtration of suspensions (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 839–843, June 1951.

Paper elaborates further on previous studies on clogging of sand filters under one-dimensional, constant-discharge flow of liquid containing fine suspended matter. The basic differential equation in t and x contains two dependent variables, the volumetric concentration of suspended matter δ and the degree of clogging of the void space in the filter by the settled solids ρ. The method of solution consists in assigning suitable expressions for δ, followed by solution of the equation for ρ. Two possible forms of δ are suggested, and two corresponding expressions for ρ are found. Neither of these two solutions, however, satisfies fully all the boundary conditions, the first being erroneous on one side of the x, t range, and the other on the opposite side. With the peculiarity of the form of the differential equation and of the expressions for δ, the difficulty with regard to the boundary conditions is resolved by utilizing both solutions on the two sides of the range after determining first the intermediate point at which one solution can be made to merge into the other. A numerical example with some charts illustrates the application of the method.

Alexander Hrennikoff, Canada

281. Tschebotarioff, G. P., Flexible bulkheads, *Dock Harb. Author.* **31,** 366, 373–376, Apr. 1951.

Based on results of comprehensive model flexible-bulkhead tests at Princeton University (USA), a new method of design is proposed for bulkheads in sand. Method reduces bending moments by about 50% with respect to those computed from the "free earth support" method; anchor pulls are more conservatively computed. Point of fixity is taken at outboard ground level with embedment equal to 0.43 times height of bulkhead above this level.

C. Martin Duke, USA

282. Verigin, N. N., On seepage from a canal into dry ground (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **79,** 4, 581–584, Aug. 1951.

Paper deals with the problem of unsteady lateral seepage of water from a canal constructed in pervious soil underlaid by an impervious stratum. It is assumed that the water quickly seeps down, filling the rectangular space with vertical sides between the free surface of the canal and the impervious layer below, after

which it commences to spread laterally with the velocity assumed independent of y coordinate and having no y component. Solution of nonlinear partial differential equation of Boussinesq, governing this flow, results in expressions for the shape of the flow region in terms of time and for the amount of discharge. An alternative solution is also obtained by linearizing the Boussinesq equation. Some remarks are made regarding the modified problem with an allowance for evaporation.

Alexander Hrennikoff, Canada

283. **Rodin, I. V., On the influence of mining on the stress state of a mountain mass** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk*, no. 12, 1763–1783, Dec. 1950.

The stress pattern produced in a semi-infinite mass of rock by the construction of a horizontal tunnel is studied by the methods of the theory of elasticity. The normal and the tangential stresses which originally existed in the rock along the periphery of the future tunnel are first determined in polar coordinates, as well as the equations of the stress field which they create in the surrounding rock and which is termed the "temporary" field. By subtracting the values of the temporary stress field from the values of the "natural" stress field which originally existed in the unweakened mass of rock, the "residual" stress field brought about by the construction of the tunnel is established. Diagrams illustrate the distribution of stresses thus obtained.

The conclusion is reached that the results are strongly affected by the values of the coefficient of lateral pressure taken to equal: $\mu = (\nu)/(1 - \nu)$, where ν is the Poisson ratio. Therefore, the results of photoelastic and other similar experiments can be valid only if the material of the model has the same value of μ as that of the rock. Gregory P. Tschebotarioff, USA

284. **Gibbs, H. J., The effect of rock content and placement density on consolidation and related pore pressure in embankment construction,** *Proc. Amer. Soc. Test. Mat.* **50,** 1343–1360, 1950.

Chief object of paper is to demonstrate effect of rock content on stability and consolidation of embankment material consisting partly of an excellent clay binder. Comprehensive laboratory tests indicate that consolidation and pore pressure decrease with increasing amount of rock, and to a greater extent than may be accounted for by solid rock volume. For equal total amounts of rock, 3-in. maximum size material showed greater consolidations and pore pressures than 1-in. maximum size, probably due to better grading of the former.

Generally, designers of large earth dams are bent on obtaining outer supporting zones of porous material with internal friction. If this material is scarce on site, intricate and important problems such as those discussed in paper may be encountered. It would seem that, in practical cases, the proper rock content in clayey material, to insure desired effect on stability, may call for certain special details in design, as well as precautions in construction, which are not dealt with in paper. P. Wilh. Werner, Sweden

285. **Vey, E., The mechanics of soil consolidation by electro-osmosis,** *Nat. Res. Counc. Highway Res. Board, Proc. 29th ann. Meeting*, 578–589, 1950.

286. **Mandel, J., On soil consolidation** (in French), *C. R. Acad. Sci. Paris* **232,** 3, 209–211, Jan. 1951.

Author treats mathematically the problem of the consolidation of a cylindrical sheet of saturated soil whose frame is supposed elastic, under an axial vertical load, by a method analogous to the determination of the natural vibrations of a domain.

R. G. A. Spronck, Belgium

287. **Hvorslev, M. J., and Kaufman, R. I., Torsion shear tests on Atlantic Muck—the Panama Canal,** *Waterways Exp. Sta. tech. Memo* 3-328, 70 pp., Aug. 1951.

In developing and calibrating a torsion shear apparatus to test Atlantic Muck, certain preliminary tests were performed on an over-consolidated specimen of Lake Providence clay. A greater number of tests were later performed on Atlantic Muck in various states of consolidation. The principal advantage of the torsion apparatus seems to be that it gives the progressive shearing resistance of a soil as a function of deformation. The reviewer believes, however, that since the errors inherent in the test, namely, the tendency of the soil to be squeezed out between the rings at the surface of shearing and the lack of control of water content during the test, can never be completely eliminated, it seems doubtful that the method could ever be much of an improvement over the simpler direct shear method, which has much the same limitations. The test results showed very good correlation, within the limits of scattering, of shear strength from unconfined compression tests, with initial shearing resistance by the torsion method; but ratios between initial shearing by the torsion method were larger than corresponding ratios between remolded and undisturbed, unconfined compressive strengths, except for strongly over-consolidated soils. Eben Vey, USA

288. **Casagrande, A., and Wilson, S. D., Effect of rate of loading on the strength of clays and shales at constant water content,** *Géotechnique Lond.* **2,** 3, 251–263, June 1951.

Effect of slow deformation or creep on the compressive strength of several soils was investigated. With creep permitted for periods up to 30 days, the ultimate strength of some soils was reduced 40 to 80%, while others remained unchanged or exhibited small increases. Stress-deformation characteristics were studied in detail. It was determined that fully saturated brittle clays and clay shales were most susceptible to loss of strength in creep tests; compacted soils and partially saturated undisturbed clays gained strength during these tests. This may explain the sudden occurrence of earth slides on slopes which have been stable for many years. Thomas L. Speer, USA

289. **Werner, P. W., and Norén, D., Progressive waves in nonartesian aquifers,** *Trans. Amer. geophys. Un.* **32,** 2, 238–244, Apr. 1951.

Paper considers seepage flow in vertical parallel planes between two vertical planes, one impervious and another fully pervious. Fluctuations due to (1) tail water-level fluctuations and (2) periodical replenishment from above, are analyzed on basis of Darcy's law and Dupuit's assumption of constant gradient along vertical lines.

Authors seem to be unaware of J. V. Boussinesq's classical paper, "Essai sur la théorie des eaux courantes" ["Mem. pres. par div. savants," Paris, 1877], in which the basic theory was developed and a number of more general problems were solved without taking into account, however, effects of replenishment. Inclusion of latter effects is present paper's main contribution.

Oscar Hoffman, USA

290. **Kalinin, S. V., On the motion of gases through sands** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 10, 1443–1449, Oct. 1950.

Apparatus is described for experimental study of gas flow through sand or other soil. Experiments were carried out for both stationary and nonstationary cases. Stationary case verifies a predicted linear relationship between the square of the absolute pressure p^2 and distance measured along the column of sand. Nonstationary cases also agree well with theoretically calculated results. R. E. Gaskell, USA

Micromeritics

291. Inn, E. C. Y., Measurement of particle size and concentration of homogeneous aerosols, *J. Colloid Sci.* **6,** 4, 368–371, Aug. 1951.

Description of adaptation of the Beckman quartz spectrophotometer for transmission methods of measuring particle size and concentration of homogeneous aerosols. The work described was carried out with glycerin aerosols of particle size between 0.3 and 0.7 μ, but it is thought possible that the method could be applied within the range of 0.1 to 1.0 μ.

Stacey G. Ward, England

292. Carpenter, F. G., and Deitz, V. R., Methods of sieve analysis with particular reference to bone char, *J. Res. nat. Bur. Stands.* **45,** 4, 328–346, Oct. 1950.

The procedure for separating particle sizes of solid adsorbent by sieving has been studied in detail because of the influence of the particle size on adsorbent properties. The largest source of error was in the testing sieves themselves. They were calibrated by the use of a calibrated sample of spherical glass beads to obtain the opening that is effective in sieving. A simple procedure is proposed to determine the uniformity of sieve openings and thereby to furnish a criterion for the discard of distorted sieves.

An analysis with seven Ro-Tap machines indicated that, in general, best results are obtained when the Ro-Tap is operated at 115 taps/min of the knocker mechanism. The other variables concerned with shaking that were examined are of minor importance and need not be rigidly controlled. As first choice, the weight of the sample should be between 100 and 150 g. The shaking time should be adjusted to the weight and the particle size distribution of the sample according to relationships developed. From the author's summary by G. H. Lean, England

293. Feifel, E., The normcyclon—an instrument of dust technique (in German), *Arch. tech. Messen* **177,** V1286–V1289, Oct. 1950.

Article presents theoretical aspects of the cyclone dust collector. A number of formulas are derived giving the relation between cyclone dimensions and gas flow and the minimum size of particle collected. No experimental data are offered to substantiate the analysis. It is not evident that the procedure outlined by author contributes much more to cyclone theory than is already available in the rather extensive literature on the subject.

J. M. DallaValle, USA

Geophysics, Meteorology, Oceanography

(See also Rev. 105)

294. Eady, E. T., The cause of the general circulation of the atmosphere, *Centen. Proc. roy. meteor. Soc.*, 156–172, 1950.

Paper is the latest of a series of attempts beginning with Hadley to explain the observed nature of the general circulation from first principles. Previous attempts have, as a rule, suffered from (1) inclusion in the circulation model being explained of aspects which existing observational data were inadequate to verify, e.g., meridional circulations, and (2) failure to follow out rigorously the consequences of each step of the argument. Author skillfully avoids both these difficulties by analyzing those processes which must be operative, and looking for their manifestations in very general aspects of the circulation.

It is deduced first that the need for the transfer of heat requires that there be an atmospheric circulation, and that this transfer must be accomplished by large-scale turbulence, because the meridional circulations required, if it were accomplished by steady motion would, result in much too large transfer of angular momentum. The existence of the large-scale turbulence is a consequence of the instability of baroclinic zonal flow shown by Eady and others previously. It is demonstrated that the proof of such instability, using perturbation methods, is valid for finite disturbances. The turbulent circulation is shown to be thermally rather than mechanically driven, and to be responsible for the maintenance of the observed latitudinal inequality of mean angular velocity of the atmosphere, rather than being due to it. The necessary structure of the turbulent disturbances, involving correlation of the westerly and southerly components of the relative wind, comes about from the latitudinal variation in the velocity of wave disturbances. Finally, the vertical transfer of angular momentum between high levels and the earth's surface is attributed to meridional circulations which are induced by surface friction and at the same time accomplish the necessary transfer to replenish the angular momentum destroyed by it.

M. Neiburger, USA

295. Houghton, H. C., and Cramer, H. E., A theory of entrainment in convective currents, *J. Meteor.* **8,** 2, 95–102, Apr. 1951.

A cloud is assumed to be a steady-state vertical jet of constant cross section; then the temperature distribution in the environment determines the vertical divergence, the temperature distribution in the cloud, and the rate of inflow of air at upper levels into the cloud, if there is no turbulent mixing. Novelty of the paper is that the rate of entrainment is computed rather than assumed. An interesting result is that the ascent through air of very low moisture content will not evaporate all the liquid water in the cloud. It is reviewer's opinion that this last result is an indication there is another type of entrainment at work, probably the turbulent mixing of Stommel, adding its effect to the type assumed in this paper. Clouds do disappear in a convectively unstable "dry" atmosphere. John C. Freeman, USA

296. Stümke, H., Theory of further development in stable atmospheric pressure fields (in German), *Meteor. Rdsch.* **3,** 4; **11/12,** 1/2; 241–243, 7–13; Nov.-Dec. 1950, Jan.-Feb. 1951.

In part I, the study uses as its starting point the concept that the atmosphere, as a system with wave-motion capabilities, contains certain modes of motion which have no bearing on the course of the weather. These superfluous modes of oscillation are, under the assumption of stable layers, suppressed so that one substitutes a mean state of the atmosphere, which simply approximates its equilibrium state. Thus, from the above pressure field may be derived, in the usual manner, the associated fields of density and horizontal wind velocity. Through time differentiation of the mean conditions the expression for the mean tendency of the derived field is calculated and introduced as a substitute for the real terms in the rigorous basic equation. One obtains in this manner, for the pressure tendency and vertical wind velocity, two related linear partial differential equations with improved solution characteristics in comparison with previous approximations. The solution should be determined under the hypothesis of level ground surface and diminishing pressure tendency at great heights. For the integration of the pressure field with time, a stepwise procedure is suggested whereby in each time interval a linear rate of increase in the succeeding time is used.

In part II, the two differential equations are treated as customary differential equations and reduced with the observance of the boundary conditions through the usual integral equations which are solved by iteration. Moreover, it must be assumed that the initial pressure distribution is an analytic function of the

horizontal coordinates or may be approximated as such with sufficient certainty. This treatment is illustrated by two examples.

In part III, an elliptical differential equation in terms of the pressure tendency is obtained through the elimination of the vertical velocity. This can be reduced, with the aid of the method of Green's function, to an integral equation in three variables, which, in general, is solved by iteration, but which for the special case of stationary isothermal atmosphere is automatically reduced to a solution in a closed integral expression. This method is likewise illustrated in an example.

Translation of author's summaries by Lester Machta, USA

297. **Fultz, D., and Long, R. R., Two-dimensional flow around a circular barrier in a rotating spherical shell,** *Tellus* **3, 2,** 61–68, May 1951.

Paper deals with some preliminary results of a new experiment to study the flow of fluid around a circular barrier and so to define the flow of air around a circular mountain on the earth. Experiment is a continuation of a previous one made in this laboratory concerning the dynamics of a fluid polar vortex moving on the earth or in a rotating spherical shell. One of the important factors in this problem involved the pressure force exerted by the surrounding fluid in the boundary of vortex. Due to various complications, knowledge of the pressure forces computed from theoretical motion was not useful in an interpretation of polar vortex experiment. So, a new experiment was carried out to study these motions in the laboratory. Paper describes the apparatus and observations, and also gives an application of the theory of two-dimensional, incompressible steady motion to the earth.

Authors conclude with some remarks on future plans and suggestions and give some references on their work. We hope they will carry their experiments further and so help in explaining some important problems of the physics of air.

Salih M. Uzdilek, Turkey

298. **Hollmann, G., Transfer of the first thermodynamic law into the hydrodynamic equations** (in German), *Z. Meteor.* **4,** 7/8, 222–229, July/Aug. 1950.

The author deals with the usual meteorological equations in which the earth's surface is approximated as plane; i.e., vertical acceleration is neglected. The earth's atmosphere is taken as a frictionless perfect gas. The author's contribution is, taking the potential temperature $\Theta \equiv T(p_n/p)\ (\gamma - 1)/\gamma$, where p_n is a reference pressure, as an independent variable, to eliminate the energy equation. The resulting system, as he points out, although valid without any particular assumption regarding the nature of energy exchange S, is not essentially more complicated than the usual one in which the motion is assumed isentropic. Let α_x, α_y denote the absolute acceleration components for a plane motion, calculated at Θ = const; let Q denote the rate of heat addition per unit mass and time; let M be the sum of the specific enthalpy and the potential energy; then the author's final equations are

$$\alpha_x + \frac{\Theta}{c_p T}\frac{\partial v_x}{\partial \Theta} Q + \frac{\partial M}{\partial x} = 0, \quad \alpha_x + \frac{\Theta}{c_p T}\frac{\partial v_y}{\partial \Theta} Q + \frac{\partial M}{\partial y} = 0$$

$$\frac{\partial}{\partial x}\left(v_x \frac{\partial p}{\partial \Theta}\right) + \frac{\partial}{\partial y}\left(v_y \frac{\partial p}{\partial \Theta}\right) + \frac{\partial}{\partial \Theta}\left(\frac{\Theta}{c_p T}\frac{\partial p}{\partial \Theta} Q\right) + \frac{\partial^2 p}{\partial \Theta\, \partial t} = 0$$

He puts the vorticity theorem of Ertel [*Meteorol. Z.* **59,** 277–281, 1942] into the following simple form (subject, of course, to his initial approximations): $W/(\partial p/\partial \Theta)$ is constant for each particle, where W is the vertical component of absolute vorticity evaluated at Θ = const. He draws some qualitative meteorological conclusions from these results, which he uses also to put the equation of Bjerknes for the meridional circulation into a simpler form.

C. Truesdell, USA

299. **Ichie, T., A note on the friction terms in the equation of ocean currents,** *Oceanogr. Mag. Centr. Meteor. Observ., Tokyo* **2, 2,** 49–52, June 1950.

Friction at the sea bottom is usually considered proportional to the velocity of the current. It is expressed as μW, where W denotes the current and μ is a proportionality factor.

Author estimates the value of μ for certain currents. He expresses the current as a complex function. By using proper boundary conditions at the surface and bottom, he solves the equations of motion and finds that, if either drift or gradient currents exist alone, μ is a simple function of both eddy viscosity and depth, provided that the latter is less than the depth of frictional influence.

Herbert Riehl, USA

300. **Lowell, S. C., The boundary conditions at the tropopause,** *Tellus* **3,** 2, 78–81, May 1951.

Relations between the derivatives of pressure, temperature, density, and velocity at surfaces where some of the quantities have discontinuities are discussed. These relations must be taken into account when constructing mathematical models of the atmosphere if internal inconsistency is to be avoided.

M. V. Wilkes, England

301. **Hodgson, J. H., and Milne, W. G., Direction of faulting in certain earthquakes of the North Pacific,** *Bull. seism. Soc. Amer.* **41,** 3, 221–242, July 1951.

This presents a further development and application of a method first exploited by Byerly. The method permits a determination of the dip and strike of a fault and direction of fault motion at the time of an earthquake from a consideration of the first motion (compression or rarefaction) observed at a number of seismograph stations. Byerly has shown that when stations are plotted in extended position, the initial motion will be compressional in two lunes of the earth and rarefactional in two others, the direction of displacement being opposite in alternate segments. The "extended" position for a station is the point of emergence of the tangent at the focus of the ray to the station. These lunes are formed by the intersection of the earth's surface with the fault plane and with a plane through the epicenter perpendicular to the motion direction. Certain geometrical consequences of the orthogonality of this second plane and the motion direction are here deduced. The extended theory is applied to four earthquakes.

James T. Wilson, USA

302. **Palmén, E., The role of atmospheric disturbances in the general circulation,** *Quart. J. roy. meteor. Soc.* **77,** 333, 337–354, July 1951.

After rather indecisive discussion of transfer of momentum across circles of latitude by a process which corresponds to negative transfer coefficient, there follows synoptic study of the process by occlusion of large masses of southward-moving subsiding cold air and formation of upper air depression. Measurements can be made only if cold air is bounded by clearly recognizable surface of discontinuity through which air does not pass. Rate of change of area of cold air to south of a fixed latitude at each level is compared with the horizontal inflow across the latitude into region enclosed by front, and it is shown that the air subsides rapidly. Trajectories in three dimensions of air particles lend point to concept. Schematic drawings of successive positions of

polar front in vertical section are set out to illustrate mechanism of cold outbreak and reformation of front to north, and, finally, a scheme for the mean meridional circulation based on concepts is drawn up.

Simplicity is compelling; indeed, idea is not new to forecasters with experience of middle latitudes, but author's achievement is to document clear-cut example of process, which has been described in greater detail elsewhere. [AMR **4**, Rev. 4023].

R. S. Scorer, England

303. Swinbank, W. C., The measurement of vertical transfer of heat and water vapor by eddies in the lower atmosphere, *J. Meteor.* **8**, 3, 135–145, June 1951.

Paper describes apparatus providing a continuous record over a five-minute period of the detailed structure of the temperature, vapor pressure, total wind speed and its vertical component.

Conventional measuring techniques are used (i.e., twin hot-wire anemometer for wind speed and direction; fine thermocouples for temperature; fine wet bulb thermocouples for humidity). The measurement of humidity utilizes an electrical circuit designed to simulate the behavior of Regnault's psychrometric equation for small changes in the variables. The measured variables are recorded with mirror galvanometers and rotating photosensitive paper.

Robert J. Mindak, USA

304. Long, R. R., A theoretical and experimental study of the motion and stability of certain atmospheric vortices, *J. Meteor.* **8**, 4, 207–221, Aug. 1951.

Circular vortexes with uniform density moving in either a zonal current of uniform vorticity or in an atmosphere originally at rest are investigated theoretically and experimentally. Lagrange's equations are set up in spherical coordinates. The axis of the vortexes is perpendicular to the surface of the earth. The vortex rotates as a solid, and there is no mass exchange with the environments. It is found that anticyclones or weakly cyclonic vortexes have a tendency to move toward the south, while strong cyclones move toward the north [cf. also Kuo, AMR **4**, Rev. 1402]. Part of the theoretical results are confirmed experimentally, using an apparatus described earlier by Fultz [AMR **2**, Rev. 1338] with slight modifications. The results are also a proof of the high value of experimental model tests for the study of large-scale atmospheric motion.

Horst Merbt, Sweden

305. Best, A. C., Drop-size distribution in cloud and fog, *Quart. J. roy. meteor. Soc.* **77**, 333, 418–426, July 1951.

Experimental data relating to drop-size distribution in cloud and fog are examined, showing that in many cases the size distribution can be represented by the formula $1 - F = \exp[-(x/a)^n]$, where F is the fraction of liquid water in the air comprised of drops with diam less than x. The constant a increases with the liquid-water content of the cloud. It is not clear what governs the value of the constant n, but a reasonable mean value is about 3.3.

It is shown that, if the drop-size distribution can be described by the equation quoted above, the median volume diam is the most suitable parameter for describing the average size of the cloud particles when the value of n is not known.

From author's summary by Phillip Eisenberg, USA

306. White, R. M., The meridional eddy flux of energy, *Quart. J. roy. meteor. Soc.* **77**, 332, 188–199, Apr. 1951.

For selected North American stations, author calculates mean total eddy transport of sensible and latent heat energies, and presents data as function of height and latitude for summer and winter.

Data show that during summer and winter there is a net eddy transport of energy northward as high as the tropopause from 30° to 70° N. latitude. South of 30° the net transport is southward. The maximum rate of sensible heat-energy (c_pT) transport occurs at latitude 55 North and elevation of 500 mbs.

Generality of results is affected by geographically restricted sources, the averaging process, and a certain selectivity of the upper air soundings. As author points out, this is unavoidable.

It should be mentioned that an earlier effort (Priestley) was limited to investigation of mean local flux, whereas present paper considers, in addition, the standing eddy flux.

Warren W. Berning, USA

307. Kleinschmidt, jun. E., On the structure and generation of cyclones (in German), *Meteor. Rdsch.* **3, 4**; 1/2, 3/4, 5/6; 1–6, 54–61, 89–96; Jan./Feb., Mar./Apr. 1950, May/June 1951.

Problem is treated with the help of Ertel's vorticity equation

$$dZ/dt = d/dt(\sigma W \text{ grad } \vartheta) = \sigma W \text{ grad } d\vartheta/dt,$$

where $\sigma = 1/\rho$, $W = 2f + \text{rot } w$, and ϑ is the potential temperature. Z is an invariant if only adiabatic changes of state are permitted. It can be shown that masses of high Z embedded in a current lead to cyclonic motion, while masses with low Z values lead to anticyclonic motion. In any cyclone, on the other hand, masses with high Z must be present at some level. The appearance of such masses may have two reasons. They have either drifted from places with different Z into their new surroundings, or the high values of Z have been created through some non-adiabatic process. Analyzing aerological charts, the existence of lens-shaped bodies with Z values different from those of their surroundings has been proved. They are often situated at the tropopause. Their structure and development are investigated and many details are given. With the aid of available wind data in a frontal zone, approximate streamlines inside the frontal wave are constructed. Mainly, two streams appear to pass the wave. In the lower one, heat release from condensation creates the cyclonic mass, where all masses with $Z > Z_{\text{normal}}$ are collected. The increase in Z can be calculated approximately from Ertel's equation. In the upper stream, the Z values of the affected masses are decreasing inside the condensation area. These masses are collected in an anticyclone in front of the wave. Thus, the flow distribution in such a wave can separate the cyclonic and anticyclonic parts so that they appear at appreciable distances from each other [cf. L. Prandtl, *Ber. Wetterdienst, Kissingen*, no. 12, 1949]. Many examples illustrate the theoretical results. Practical application for daily forecasting is rather restricted, as the determination of Z fields from weather charts is very laborious. But the method may help to improve our knowledge of atmospheric phenomena.

Horst Merbt, Sweden

308. Prescott, J. A., and Stirk, G. B., Studies on the Piche evaporimeter, *Austral. J. appl. Sci.* **2**, 2, 243–256, June 1951.

Evaporation from Piche evaporimeter is shown by tests to be more highly correlated with wet-bulb saturation deficit (difference in saturation vapor pressure e_s at wet-bulb and dewpoint temperatures of air) than with atmospheric saturation deficit (difference in e_s at air and dewpoint temperatures), and correlation is high enough to afford a measure of the former, as well as of daily vapor pressure or humidity when combined with temperature and pressure measurements. As an index of actual evaporation, from free water surface or otherwise, instrument has same weaknesses as others, in that natural conditions are not simulated. Effect of wind speed is illustrated and means are suggested for separating wind and vapor-pressure effects.

Ferguson Hall, USA

309. **Roberts, E. A., and Goldsmith, P., Piezoelectric crystals as sensing elements of pressure, temperature, and humidity,** *Elec. Engng.* **70,** 9, 776–780, Sept. 1951.

Piezoelectric crystals have many properties which make them highly suitable for detecting atmospheric conditions. Some of the techniques for using them are described.

From authors' summary

310. **Brun, R. J., Levine, J., and Kleinknecht, K. S., An instrument employing a coronal discharge for the determination of droplet-size distribution in clouds,** *Nat. adv. Comm. Aero. tech. Note* 2458, 53 pp., Sept. 1951.

Size distribution of droplets, in clouds above freezing temperatures, is measured by charging droplets in an electric field and allowing them to impinge on collecting cylinders of different diameter. The droplets are separated, according to mass, by flow around the larger cylinders. The charge deposited on each cylinder is a measure of the size distribution, when the collection efficiency is known.

A derivation is given of the electric field equation used and of the rate of acquisition of charge by water droplets. A flight instrument used to evaluate the method indicated required improvements in technique. H. M. Spivack, USA

311. **Gutenberg, B., PKKP, P′P′, and the earth's core,** *Trans. Amer. geophys. Un.* **32,** 3, 373–390, June 1951.

Author gives revised travel-time curve for longitudinal waves between points of core, based on seismograms available at Pasadena. Observed amplitudes in P′ and PKKP are about four times greater than estimated. PKKP is not observed through inner core, but the fact that it gives large amplitudes through outer core indicates density ratio of at least 1.7 on crossing from mantle to core.

The velocity of P waves on crossing boundary of inner core changes from 10 to 11 km/sec in a distance of 100 km. This is a less abrupt transition than that suggested in the work of Jeffreys [*Mon. Not. roy. Astr. Soc. Lond. geophys. Suppl.* **4,** 548–561, 594–615, 1939].

From author's summary by J. M. Jackson, Scotland

Lubrication; Bearings; Wear

312. **Huetz, J., Contribution to the study of oil wedges** (in French), *C. R. Acad. Sci. Paris* **232, 21,** 1906–1908, May 1951.

Results of two modifications in the viscometer described previously [see AMR **2,** Rev. 150].

313. **Späth, W., Remarks on the wear problem** (in German), *Schweiz. Arch.* **17,** 7, 214–219, July 1951.

Author discusses possibilities of gaining better insight into the complicated phenomenon of wear. He stresses the expediency of establishing clear and suitable concepts, and proposes various concepts; e.g., "destruction velocity" (reciprocal of endurance) and "softness" (reciprocal of hardness). The usual hardness testing does not give a useful measure of the wear properties of a material, since too large a part of the surface is considered. Somewhat more suitable are the microhardness testing and the Ritz test, since they detect better the properties of the texture. Here the static hardness tests give little information, since the wear is a dynamic phenomenon. The determination of the long-time alternating-hardness ("Dauerwechselhärte"), for which the author gives a simple device, seems to be especially suitable. Referring to one of his explanatory tests for the grinding phenomenon, it is shown that a comparison with other domains of science may be advantageous. The article contains numerous literature references. Hans Drescher, Germany

314. **Blok, H., Gear lubricant—a constructional gear material,** *Ingenieur* **63,** 39, 0.53–0.64, Sept., 1951.

The power-transmitting capacity of highly loaded tooth gears is influenced by their lubrication. Hydrodynamic lubrication (full fluid film) is seldom realized in tooth gears. The lubrication is generally a boundary lubrication (the load borne by direct contact tooth to tooth), and the scoring of the tooth faces may be a critical phenomenon; this often can be avoided by using special oils, the so-called extreme pressure (E.P.) oils, which contain chemically active additives.

Main purpose of paper is to develop some thoughts that can contribute to the further development of our knowledge (at present still in an initial stage) of the constructional properties of gear oils.

A very useful bibliography is given at the end.

A. R. Holm, Denmark

315. **Heidebroek, E., and Hagedorn, Calculation of the friction heat and the necessary amount of cooling-oil for high-speed journal bearings** (in German), *Technik* **6,** 1, 21–23, Jan. 1951.

Paper outlines method for calculating the amount of oil supply necessary for controlling the temperature of high-speed journal bearings. The method is based on theoretical and experimental work, by other German investigators, on the relationship between coefficient of friction and Sommerfeld's hydrodynamic bearing parameter. Minimum oil-film thickness is checked with regard to possible contact, and consequent seizure, of bearing and journal.

H. Blok, Holland

Marine Engineering Problems

316. **Russo, V. L., and Robertson, J. B., Jr., Standards for stability of ships in damaged condition,** *Trans. Soc. nav. Archit. mar. Engrs.* **58,** 1950.

Authors discuss at length many aspects of Regulation 7, Chapter II, promulgated by the 1948 International Conference on Safety of Life at Sea. Regulation 7 prescribes general design standards for the stability of ships in damaged condition. Paper emphasizes importance of transverse stability and studies effects on design of extent of damage, of maximum permissible condition in damage, of hull form and arrangement and configuration of flooded spaces. Methods of meeting regulations with minimum intact stability are discussed. Effects of both isolated and cross-connected wing tanks on required GM are summarized from a study made for C3-type vessel. Means of estimating intact stability are discussed and an empirical formula for righting arm given by Niedermair [title source, **40,** 1932] is verified by results of model stability tests reported in this paper. Need is emphasized for imparting practical methods of estimating ship stability to shipboard personnel. Authors review existing techniques and present a new method for estimating daily stability condition of a ship which is claimed to be sufficiently simple and brief for practical use by nontechnical personnel aboard ship.

John P. Breslin, USA

317. **Lackenby, H., On the systematic geometrical variation of ship forms,** *Trans. Instn. nav. Archit. Lond.* 92, 3, 289–310, July 1950.

When change $\delta\phi$ of prismatic coefficient of foreward or after half-body of parent ship is required, it has been more or less cus-

tomary to achieve this by altering each abscissa x (or fractional distance of any transverse section from midships) of curve of section areas by amount $\delta x = \delta\phi(1 - x)/(1 - \phi)$. This implies alteration of fractional length p of parallel middle of half-body of $\delta p = \delta\phi(1 - p)/(1 - \phi)$. p and ϕ, therefore, cannot be varied independently, and the process cannot be applied to reduce fullness of ship basis, which has no parallel middle body.

Author proposes to alter length of parallel middle body independently of entrance or run. According to this proposal, alteration of abscissa x of entrance or run considered separately should be $\delta x = cx(1 - x)$, where c is constant. If associated with parallel middle half-body, shift of sections should be $\delta x = c(x + d)(1 - x)$ where c and d are constants. Value of constants can easily be found from change wanted in parallel body and in entrance or run.

Georg Vedeler, Norway

318. Panagopulos, E., Design-stage calculations of torsional, axial, and lateral vibrations of marine shafting, *Trans. Soc. nav. Archit. mar. Engrs.* **58,** 329–384, 1950.

Paper covers most of the basic vibration problems associated with low-speed marine installations. While mathematically the approach is somewhat elementary, a good many sound design principles are expounded. Although it is doubtful that the experienced vibration analyst will find much of interest in the paper, the design engineer who is called upon to check his work from the dynamic viewpoint will probably profit from it. Reviewer emphasizes that only the low-speed régime is discussed.

Walt Targoff, USA

319. Allan, J. F., and Conn, J. F. C., Effect of laminar flow on ship models, *Trans. Instn. nav. Archit. Lond.* **92,** 1, 107–120, Jan. 1950.

Previous experimental techniques and the reasons for modifying them are described in the introduction. These modifications are necessitated by large scatter in the results of frictional resistance of models and the inability to extrapolate from them to full-scale ships. The existence of laminar and transitory boundary layers over the forward region of the model surface was suspected of causing the scatter in the experimental results. The use of trip-wires or other turbulence-stimulating devices at some station of the bow or ahead of it seems to be necessary when conducting tow experiments with small models at low speeds.

The physics of the boundary layer are discussed briefly. (A very short résumé of the boundary-layer theory is given in the appendix.)

Towing tests were made with a B.S.R.A. standard model of 0.75 block coefficient. The effects of various turbulence-producing devices are given. The influence of the trip-wire diameter is also described. At decreasing draught, the effect of the turbulence-producing devices diminished.

The area over which laminar flow exists on models has been investigated. Attempts to develop suitable hot-wire techniques failed. Ink-streams of 0.05-in. diam were released from various points of the hull and their behavior studied. Total-head tube exploration of the boundary layer was also made. Pressure distribution on the model surface along streamlines (chosen along the path giving maximum length of laminar flow and the region of transition) was measured. The laminar flow areas over various models together with the wave profiles are given in graphs.

The effect of heavily sloped stem on transition is described. The effect of the trip-wire at higher speeds is discussed.

In conclusion it is remarked that the investigations made are incomplete. It is suggested that trip-wires be used on all future model tests. It is also pointed out that other factors, such as conditions of bottom surface, weather, ship-surface roughness, etc., make it difficult to arrive at accurate conclusions.

Paul Torda, USA

320. Lerbs, H. W., An approximate theory of heavily loaded free-running propellers in the optimum condition, *Trans. Soc. nav. Archit. mar. Engrs.* **58,** 137–183, 1950.

Paper records important development of vortex theory of propellers in homogeneous flow in condition of minimum energy loss. Previous treatises of author are confined to small or moderate loading coefficients. His successful efforts to work out Helmbold's original theory for practical application in the field of marine propellers are now extended to conditions of heavier loading. This implies allowances for contraction and for radial pressure gradient of slip stream of screw with finite number of blades. As distinct from Theodorsen's work, author's deductions are not restricted to small values of Betz's displacement velocity. Power input, thrust, and efficiency are first related to supposed vortex-sheet flow conditions far behind, then to flow at blades for non-viscous medium. After numerical evaluation of this theory, relation to forces in viscous flow is considered. Numerical application to propeller design is presented, including a number of diagrams. In numerical example, the result of extended theory is plausibly related to lightly loaded propeller in simplified theory. In appendix, striking agreement is found with result derived from methodical series.

L. Troost, Holland

321. Weinblum, G. P., with a contribution by Blum, J., The wave resistance of bodies of revolution, *David W. Taylor Mod. Basin Rep.* 758, 58 pp., May 1951.

Following a brief review of prior work on wave-resistance bodies of revolution carried out by Havelock and Weinblum, a discussion is presented of the approximate relations between the shape of sectional-area curves and of hydrodynamic irregularity distributions. The latter are expressed by polynomials, which lend themselves to an evaluation of the basic resistance integrals by computing intermediate integrals. Values of the functions thus obtained are tabulated in an appendix. These functions are then used to calculate the resistance of some simple bodies of revolution. Also investigated is how the resistance is influenced by asymmetry with respect to midship section. Distributions leading to bodies of least wave resistance are calculated, assuming rather severe restrictions. A rather complete set of resistance curves is given for an important family of bodies.

From author's summary by F. E. Reed, USA